POWER

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Casey at the Coal Pile

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The Engineer Tells His Troubles

By Josh Weller

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IT seems I'm always joining church or being fired out;
I've been baptized full forty times or somewhere thereabout.
My pastor says that when he calls to see me at my work,
He either finds me singing psalms or cussing like a Turk.
He also says it fills his pious soul with pain and sorrow,
To find me good, because he knows I'll be all bad tomorrow.
I lay it all to Casey, darn his hair and hide and gizzard,
His stomach, lungs and all his works clear through from "A to izzard."

This Casey fellow bucks the coal to keep our boilers going.
We either have no steam at all or else the safety's blowing.
The coal he wastes for us each day would run two plants like ours,
This waste destroys my peace of mind, my disposition sours.
And when I remonstrate with him, consarn his bilious liver,
He tells me to go chase myself and jump into the river.
My job, you know, depends upon this matter of expenses,
I must keep down the fuel bills or take the consequences.

And when the coal man comes around and says, "six hundred dollars,"
I shake and quake to hear the way the old man swears and hollers.
He comes into my engine room, his face with wrath is burning,
He makes things hot and red and blue with damning and with durning.
I think my job is gone for sure, despair engulfs my soul,
While Casey merely grunts and spits and "fills her up" with coal.
And when the old man goes at last, my soul for gore is thirsting,
I simply have to open up and cuss to keep from bursting.

o o o

I don't know how it all will end, my heart is heavy, very;
I'd fight him but I do not dare, for Casey comes from Kerry.

Power Plant of the Edmonton Portland Cement Co.

By A. G. Christie*

SYNOPSIS—A plant compact in design, with special attention given to the piping, which is as short as possible. High steam velocities are allowed, with consequently smaller pipe sizes. The plant cost, complete, $143,300; the itemized costs are given.

The Edmonton Portland Cement Co.'s mill at Marlboro, 135 mi. west of Edmonton, Canada, is equipped throughout with motor drive. When the plant was first projected, about 1912, it was intended to install a simple, cheap power plant without particular regard to steam economy, as coal is cheap; hence a comparatively small amount of money was appropriated. On second thought it was decided, on account of the high cost of labor, to install the most economical plant possible. The problem then was to build such a plant with the money set aside for the cheaper installation.

Several points considered in choosing the location of the power plant relative to the remainder of the mill were the dust nuisance, the available water supply for condensing purposes, small transmission losses, coal-storage facilities and switching accommodation. The location finally selected was at the northern end of the mill; the prevailing winds made this a favorable site as regards dust. The plant consists of a boiler room 44x77 ft. and an engine room with basement 34½x63 ft.

Coal is delivered on a switch that leads to a trestle at the power house. The cars are unloaded into a hopper

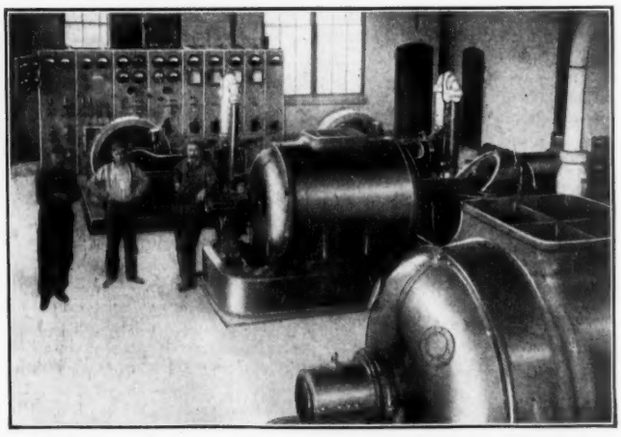

FIG. 1. PARTIAL VIEW OF THE TURBINE ROOM

with a chute that will carry the coal into the lower run of a gravity bucket conveyor, as shown in Fig. 3. This conveyor elevates the coal into parabolic suspended steel bunkers of 300 tons' capacity from which it is fed through spouts to the stoker hoppers. A special sifting hopper is provided under each stoker and the siftings are returned to the coal bunkers by the same conveyor, which is driven by a 5-hp. 125-volt direct-current motor.

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The coal-grinding and storage buildings are adjacent to the power house. Chutes have been installed so that coal can be delivered from the conveyor in the coal buildings into the conveyor in the power house. This arrangement

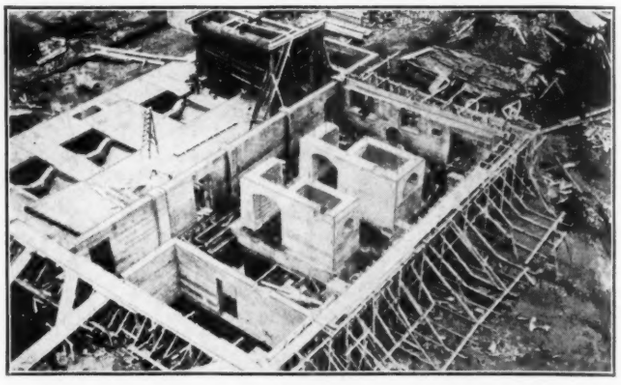


FIG. 2. ENGINE AND BOILER FOUNDATIONS DURING CONSTRUCTION

made unnecessary any great storage capacity for coal in the power plant.

The same conveyor is arranged so that the ashes may be hoed into it from the ashpits and elevated into a steel bunker and afterward loaded into wagons.

The boiler-room design embodies some interesting features. The suspended coal and ash bins are carried on one side by the outside building wall and on the other by the same steelwork that carries the boilers and the roof trusses. This made the steel construction simple and inexpensive and the boiler room much narrower than the usual practice. Only sufficient room is provided in front of the boilers to permit the withdrawal of the chain-grate stokers for repairs. Windows were provided opposite the tube headers of each boiler, to be opened when it is necessary to renew a tube. The tunnel in front of the boilers extends to the outside walls and allows plenty of room for handling tools in removing ashes. Fig. 2 shows both engine- and boiler-room foundations during construction.

There are four 350-hp. water-tube boilers, 160 lb. pressure, arranged in batteries of two. Vertical baffling is used in the tubes. Each boiler is fitted with a chain-grate mechanical stoker 8 ft. wide and with 76½ sq.ft. of grate surface. A 6-ft. inclined flat arch is suspended above the stoker from the steel frame of the setting. The stokers are driven from a lineshaft in front of the boilers and above the stokers. This shafting receives its power either from a 5x5-in. vertical engine or a 5-hp. motor placed on an elevated platform between the two batteries of boilers.

The flue gases pass into a steel breeching built above the boilers. This breeching increases in cross-sectional area toward the chimney, which is of reinforced concrete, 175 ft. high above the base and 7 ft. 3 in. diameter.

One of the features of the plant is the high-pressure steam-piping system, designed as short and as direct as possible to reduce first cost and radiation losses, and by

the extensive use of bends to have a minimum number of joints. Much higher steam velocities were allowed, and consequently smaller pipe sizes were used than in standard practice. It was held that friction losses are not of so great relative importance in a steam-turbine plant as is commonly supposed. The subsequent operation of this plant seems to support this contention.

The main header is a 14-ft. length of 7-in. pipe supported above the rear of the boilers, as shown in Fig. 4. At one end there is a 7-in. sectioning gate valve. Special manifolds with five outlets are placed beyond the gate valve and also at the other end of the header. Two of these branches are for the 6-in. headers from the boilers; a third serves as the outlet for the pipe leading to one of the main turbine units. Directly below this outlet there is another flange, to which a drip pocket is connected. This receiver catches all the moisture lying on the pipe and delivers it to a trap. The outlets on the ends are for the steam pipes serving the auxiliaries.

The pipe connection from the boilers to the manifolds consist of a bend and an elbow on the first battery and two bends on the second battery of boilers, as shown in Fig. 3. Each connection contains a gate valve and an automatic nonreturn valve placed in the highest point of the pipe to prevent accumulation of water. The bends are of increasing height from the boilers nearest the chimney in order to clear the breeching.

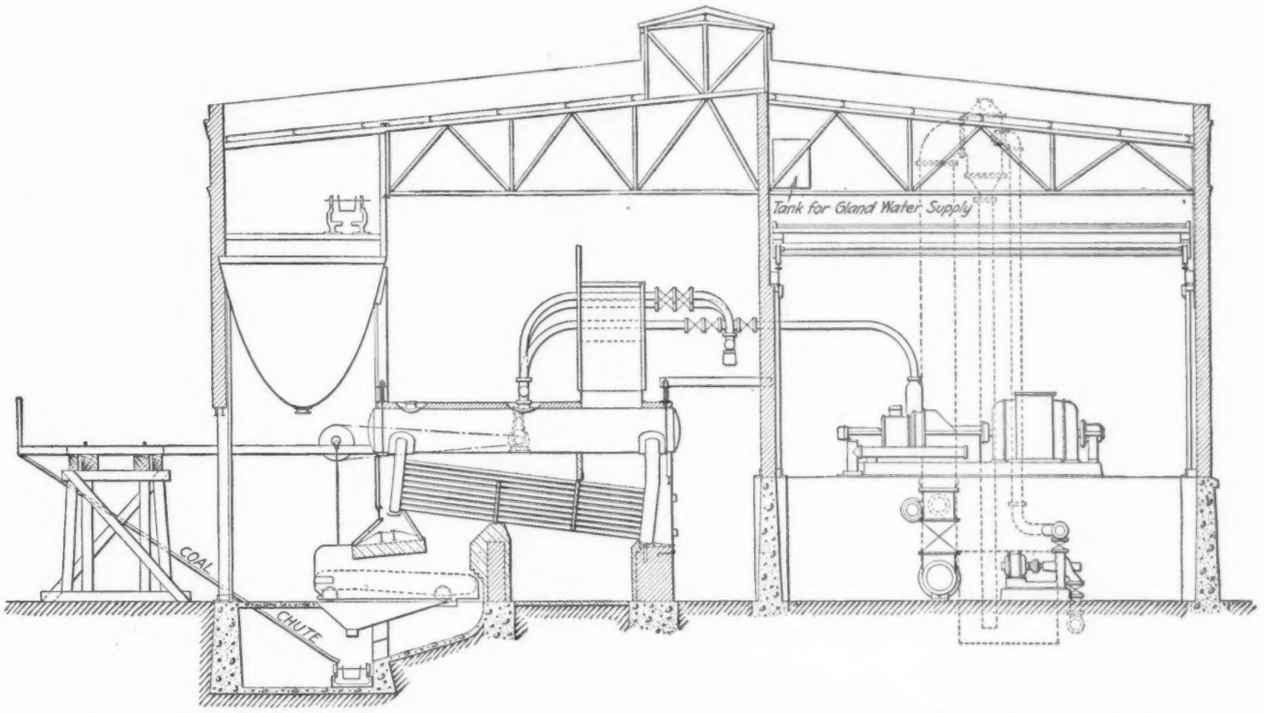


FIG. 3. CROSS-SECTION THROUGH THE BOILER AND TURBINE ROOMS; ALSO SHOWING COAL CHUTE

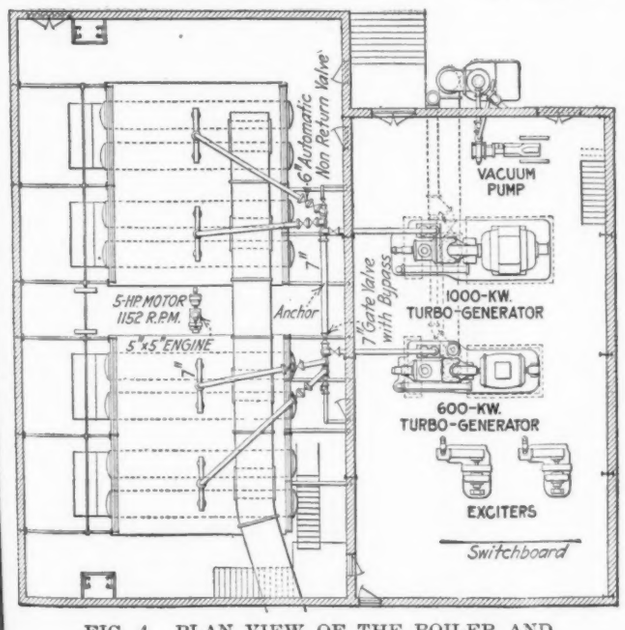


FIG. 4. PLAN VIEW OF THE BOILER AND TURBINE ROOMS

The connections to the two main turbines consist of elbows above the manifolds, then a gate valve followed by a long bend. Vertical separators are placed above the turbine throttle valves.

The steam lines to the auxiliaries consist of double bends from the header manifolds into the engine-room basement. A cross-connecting line in the basement joins the two pipes from the main header. Forged-steel flanges were used throughout.

The blowoff pipes lead into 45-deg. Y's in a 4-in. line which leads to the waste canal outside the plant.

Two 7½x4½x6-in. duplex boiler-feed pumps with brass pot valves and outside-packed composition plungers are placed in a shallow pit in the basement under the exciter end of the engine room. They can obtain water from four sources—from the feed-water heater, from the condenser hotwell, from the town water tank and from the condenser pumps' intake. These are shown in Fig. 5. These connections provide for the most economical operation possible under any emergency conditions.

Two duplicate 3-in. feed lines are carried by bends to the front of the boilers, where each has an independent means of feeding the drums. Connections are provided so that one of the boiler-feed pumps can be run on cold

water to drive the turbine tube cleaners when cleaning boilers, while the other is used for feed purposes.

The 1,000-hp. feed-water heater, also placed in the engine-room basement, receives all trap discharges and utilizes all the exhaust steam from the auxiliaries. It has a water capacity of 63 cu.ft. and a filter area of 22 sq.ft.

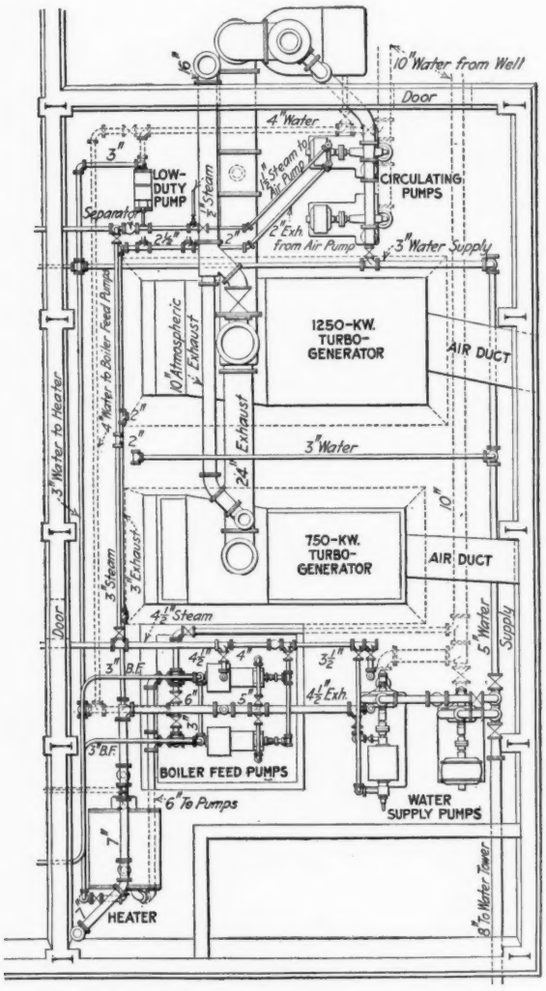


FIG. 5. PIPING OF BOILER-FEED SYSTEM

A low-service 5½x4¾x5-in. duplex pump is placed in the basement to lift water from the hotwell to the feed heater and to provide water for washing floors, wetting down ashes and similar purposes.

The turbine room, Fig. 1, contains two standard American Parsons turbines of 600-kw. and 1,000-kw., rated capacities running at 3,600 r.p.m. The generators were wound for 80 per cent. power factor and were guaranteed to have a temperature rise not exceeding 50 deg. C. after 24 hr. at one and one-quarter times full load. This gives them ample overload capacity.

The larger turbine alone can handle all the mill load. The smaller machine serves as a reserve unit to prevent any possible shutdown. It can carry all the mill but the finishing end, which, however, does not suffer materially in standing idle.

Three-phase current is generated at 600 volts. Outside air for cooling purposes is conducted to the generators in galvanized-iron ducts.

The turbines exhaust into a common exhaust pipe which leads to a barometric condenser placed outside the engine room. A gate valve and an expansion joint are placed between each turbine and the exhaust pipe. The condenser is capable of handling 25,000 lb. of steam per hour at 28-in. vacuum. Cooling water may be supplied to it by either of two 8-in. centrifugal pumps in the engine-room basement, driven by 25-hp. direct-current motors. Vacuum is maintained by a steam-driven rotative dry-vacuum pump placed on the main floor.

The land to the northeast of the power house is low and marshy. A canal was dug connecting a near-by creek, with an ample supply of very cold water, to a well near the power house. The suctions of the circulating and other pumps are connected to this source of supply, as shown in Fig. 5. Another canal leads the discharge water from the condenser to a lake about two hundred yards distant. All suction piping is flanged.

Each turbine is supplied with an automatic relief valve that connects to a noncondensing line leading outside and up the wall by the side of the condenser.

Previous experience with a similar condenser had shown that a certain amount of condensed steam always collected in the bottom of the exhaust pipe. In order to avoid scaling of the water-sealing glands where the spindle passes through the turbine casing, it was decided to utilize this water as a gland supply. A small float-controlled pump was installed to drain the exhaust pipe and to lift this water into a receiver of about 28 cu.ft. capacity placed in the roof trusses, as shown in Fig. 3. The water then flows by gravity to the glands of the turbines. Any surplus water flows through a loop trap to the feed-water heater.

The exciter units consist of two 9x10-in. horizontal automatic high-speed engines of 75 hp. running at 330 r.p.m. with 40-kw. 125-volt direct-current generators mounted on the same shaft. Besides providing exciting current to the alternators, they are used to drive certain direct-current motors in the power plant and in the machine shop and also provide some of the lights.

The lighting system of the power house and of a portion of the adjacent mill buildings is so arranged that it may be shifted either on one of the exciter sets or on the alternating-current system, depending on the amount of exhaust steam needed to heat the feed water to its maximum temperature.

All steam-driven auxiliaries exhaust into pipes leading to the feed-water heater. The outlet of the heater is

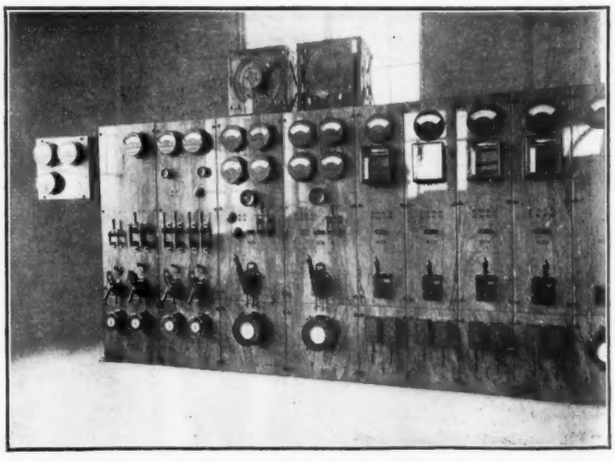


FIG. 6. VIEW OF THE SWITCHBOARD

PRINCIPAL EQUIPMENT OF POWER HOUSE OF EDMONTON PORTLAND CEMENT CO., EDMONTON, ALTA., CANADA

No.	Equipment	Kind	Size	Use	Operating Conditions	Cost	Maker
4	Boilers	Water-tube	350-hp.	Produce steam	160 lb. working pressure, no superheat	$23,000.00	Goldie & McCulloch.
4	Stokers	Chain-grate	76½ sq.ft.	Burn coal	Either engine- or motor-driven	8,000.00	Laclede-Christy Clay Products Co.
1	Conveyor	Bucket		Handles coal and ash	Motor-driven	4,000.00	Link-Belt Co.
1	Chimney	Reinforced-concrete.	175 ft. high, 7 ft., 3 in. diam.	Produces draft	Takes flue gases from boilers	4,300.00	Weber Chimney Co.
2	Boiler-feed pumps	Duplex, outside-packed	7½x4½x6-in.	Furnish feed to boilers.	With pressure governors	750.00	John McDougall Co.
1	Service pump	Duplex	5½x4½x5-in.	Plant water-supply	With pressure governor	250.00	John McDougall Co.
1	Feed-water heater	Blake-Knowles	1,000-hp.	Heats feed water	Utilizes all auxiliary exhaust steam	750.00	John McDougall Co.
1	Turbo-generator	Parsons	1,000-kw.	Produces current	3,600 r.p.m., 80 per cent. power factor, 160 lb. steam	30,500.00	Allis-Chalmers Co.
1	Turbo-generator	Parsons	600-kw.	Produces current	3,600 r.p.m., 80 per cent. power factor, 160 lb. steam		Allis-Chalmers Co.
1	Turbine	Impulse	35-hp.	Drives centrifugal pump			Terry Turbine Co.
1	Condenser	Barometric	25,000 lb. of steam per hr.	Produces vacuum on turbines	Very cold water-supply	4,650.00	Alberger Condenser Co.
2	Exciter sets	Engine-driven	40-kw.	Produce d.-c. for excitation and motors	330 r.p.m., high-speed automatic engines	3,750.00	Engines—Robb Engineering Co. Generators—Allis-Chalmers-Bullock Co.
1	Switchboard	Gray-marble	9 panels	Main distribution board	All Weston instruments	5,400.00	Northern Electric Co.
2	Centrifugal pumps	Single-stage	900 gal. per min.	Serve general water system	One driven by 35-hp. motor, the other turbine-driven	2,500.00	John McDougall Co.
1	Water tank	Elevated stave tank	50,000-gal.	Serves as reservoir		3,200.00	Pacific Coast Pipe Co.
1	Smoke breeching	Steel		Carries flue gases to chimney		1,000.00	Gorman, Clancy & Grindley
1	Piping system			Steam piping, exhaust piping	Water piping, condenser piping	14,500.00	Pittsburgh Piping & Equipment Co.
1	Crane	Hand traveling	15-ton	For construction purposes		1,500.00	Canada Foundry Co.
	Pipe covering					1,100.00	
	Wiring					450.00	
	Clearing and grading site and building foundations					7,800.00	
	Machinery foundations					1,900.00	
	Building and fixtures, coal and ash bunkers, trestle and spur track					20,000.00	
	Canals and well					3,000.00	
	Miscellaneous tools, machines and supplies					1,000.00	
					Total	143,300.00	

provided with an automatic valve that can be set to produce back pressure in the heater, if desired. A pipe leads from this valve through the roof to an exhaust head.

The nine-panel switchboard, Fig. 6, is of gray marble. Two panels are for exciters and for direct-current distribution, with integrating wattmeters on each circuit, besides the usual board instruments. There are two main generating panels also with integrating wattmeters and other instruments, and four alternating-current distribution panels with recording wattmeters. The longest distribution circuit is about 800 ft., so that the transmission losses are small. One panel is for the lighting of the mill and town and contains an integrating wattmeter. The lighting transformers are placed in a room under the switchboard and walled off from the rest of the basement. The oil switches are mounted on the back of the board, as they carry only 600 volts.

It was necessary to provide some means of supplying water to the mill and town for fire protection and for general use. A small pumping plant was installed in the power house and a wooden-stave water tank of 50,000-gal. capacity was erected close to the plant on a tower 70 ft. high.

The water in the creek is suitable for domestic supply and for drinking purposes. Being practically free from mineral salts, it makes an excellent boiler-feed water as well.

Two single-stage 6-in. centrifugal pumps were installed in the basement of the power house below one of the exciter sets as shown in Fig. 5. Each has a capacity of 900 gal. per min. against a head of 86 ft. One is driven by a 35-hp. direct-current motor, and the other is connected to a 35-b.hp. turbine. The piping is so arranged that either or both can pump into the tank and distribution system for general service. In case of fire the two pumps are put in series and a valve is closed, cutting off the tank from the distribution system. This provides a head on the mains of 170 ft. for the fire nozzles.

The distribution of the first cost of the plant, according to the cost sheets of the engineers is practically as given in the accompanying table of principal equipment. These figures are regarded as remarkably low when consideration is given to the remoteness of the plant, which made freight rates excessive, and to the high cost of labor, brick and cement.

The plans were prepared by Messrs. Hassan & Klossoki, consulting engineers and cement-mill experts, Edmonton, Alberta, and construction was carried on under their supervision.

Substation Operating Costs—The cost of transforming energy in seven substations from three-phase 13,200-volt alternating current to 600-volt direct current was recently analyzed by the Massachusetts Northeastern Street Railway in a hearing before the Massachusetts and New Hampshire public service commissions. Last year the company purchased 10,306,324 kw.-hr. from the Rockingham County Light and Power Co., of Portsmouth, N. H., the energy being metered on the alternating-current side of the substations. The price was 1.4c. per kw.-hr., making the total bill $144,288.53. The substations delivered at the direct-current busses 9,018,023 kw.-hr., the average loss in each substation being 12.5 per cent., with a range of from 8 to 16 per cent., depending upon the substation load factor. The cost of substation operation was $14,317, of which maintenance came to $2,562.07, wages $10,804.30, and supplies $950.72. The net cost of transformation and conversion per kilowatt-hour of direct current was about 0.16c. The combined rating of the substations is 4,500 kw.

Reduction in Rates—The Washington State Public Service Commission recently held that the rates charged for both residential and commercial lighting by the Puget Sound International Railway Co., at Everett were unjust, suspending the present rates and substituting a new schedule, which marks a sharp reduction from the old tariff. The new rates provide that for residential lighting the cost per kilowatt-hour after the first 20 kw.-hr. per month shall be 7.7c., the old rate being 8.88c.; the second 20 kw.-hr. per month shall be at 5.5c. per kw.-hr., and all over 40 kw.-hr. per month 3.3c. The old rate provided that all over 60 kw.-hr. would be charged at the rate of 6.66c. Proportional reductions are made in commercial lighting, the new rates being from 7.11 to 3.33c. per kw.-hr. in place of the old rates of from 8.88 to 3.88c. per kw.-hr.

Nonreturn Stop Valves--II

SYNOPSIS—A continuation of short descriptions of various types of nonreturn stop valves, which prevent steam from returning to a boiler in which the pressure is below that in the main header. A variety of nonreturn stop valves are also designed to prevent the flow of steam in either direction in case of a marked decrease in steam pressure.

A number of nonreturn valves are made in the angle type. This is the case with the Powell "White Star" nonreturn valve, Fig. 15. The disk *A* and the piston *B* have a screwed joint and are prevented from working loose by screws. The disk and piston are guided by the spindles

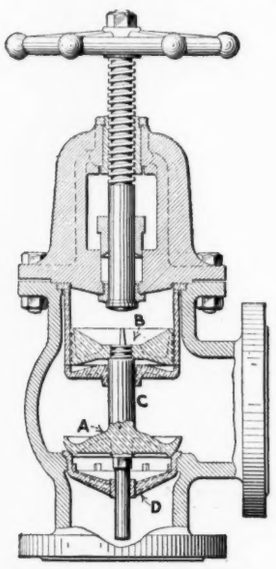


FIG. 15. POWELL NONRETURN VALVE

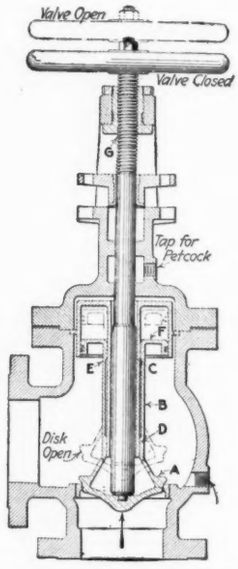


FIG. 16. PITTSBURGH NONRETURN VALVE

C and *D*, which slide in the guides formed at the bottom of the dashpot and valve seat respectively.

The dashpot fits snugly in the valve body, as shown, and is held in place by the valve bonnet, which contains a bronze bushing. This is to form a seat for the end of the valve stem, so that when it is backed against the bushing the stem can be packed with full boiler pressure on it. The valve will shut off the flow of steam from a header to a boiler if the pressure is greatly reduced, but it can be opened again only by the pressure in the boiler becoming equal to that in the steam line. The valve is placed vertically.

Pittsburgh Valve, Foundry and Construction Co.'s Nonreturn Valve

The valve shown in Fig. 16 consists of a check valve *A*, a dashpot to prevent the check from hammering and a screw-down closing wheel. The check valve is guided to its seat by the sleeve *B*. It slides on the spindle *C*, which is a part of the dashpot, and has a bearing at the top and bottom, as at *D* and *E*.

The dashpot is open at the end, which prevents any accumulation of foreign matter in it, and the diameter of the piston *F* is the same as that of the valve disk *A*. This balances the downward and upward thrusts of the pulsations of the steam. The cylinder of the dashpot has an outside ring that fits in a recess in the body of the valve, the cap when screwed down holding it in place. The piston is fitted with a small ring. The valve stem *G*, when screwed down, forces the valve disk to its seat. The stem can be packed with steam on the valve. The inlet-steam pressure, as in other valves of this type, is below the disk *A*.

Schütte Stop Check Valve

The valve shown in Fig. 17 has a disk *A* at one end and a piston *B* at the other. It is guided by the valve stem, which extends with a sliding fit into the valve. This valve has no dashpot, the chamber above the piston *B* being a cylinder in which a constant steam pressure is maintained above as well as below the seat. If the pressure in the boiler falls below that in the header, the pressure above the piston *B* forces the disk *A* to its seat. It can also be used as a stop valve by operating the handwheel. The stem *C* can be packed while the valve is under pressure.

The stop check globe valve, Fig. 18, is placed in vertical pipe lines with the spindle horizontal. The valve has a spring *A* that exerts its tension against the steam pressure that forces the valve disk *B* from its seat.

Schütte Emergency Stop Check Valve

The valve shown in Fig. 19 contains the combined features of an automatic stop check valve and an emergency feature whereby the valve may be quickly closed

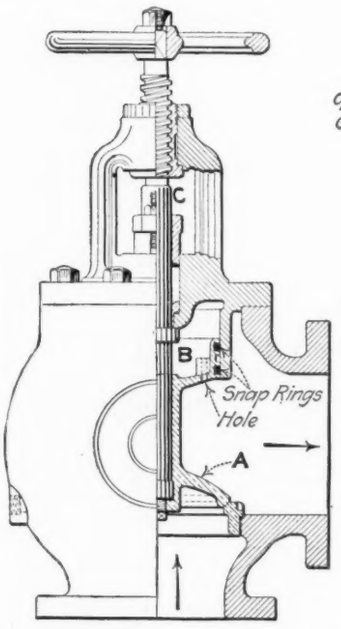


FIG. 17. SCHUTTE STOP-CHECK VALVE

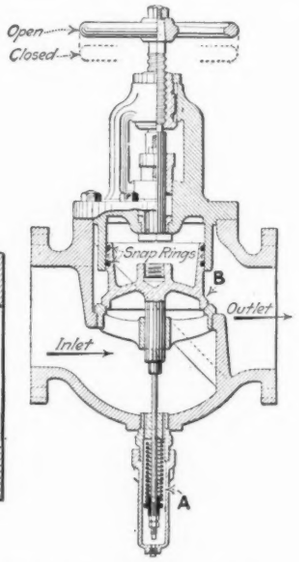


FIG. 18. SCHUTTE STOP-CHECK VALVE

from a distance by relieving the pressure under the bottom piston *A* in the cylinder *B*, in the event of a break in the steam line beyond the boiler. The closing may be effected by hand, by opening a valve in the pipe connected to the outlet *C*, or automatically by a pilot valve.

The upper part of the valve contains a dashpot *D* and piston *E*, the latter being in one piece with the valve disk and lower piston. The valve may be closed by the handwheel by screwing the stem in. The pilot valve is attached to the end of the relief pipe and is piped with

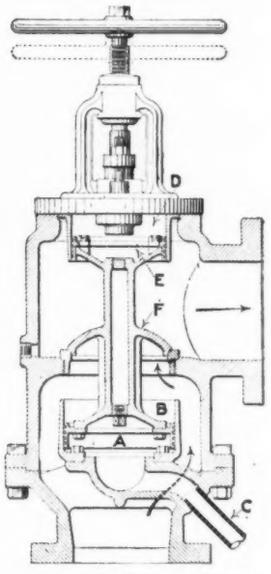


FIG. 19. SCHUTTE EMERGENCY VALVE

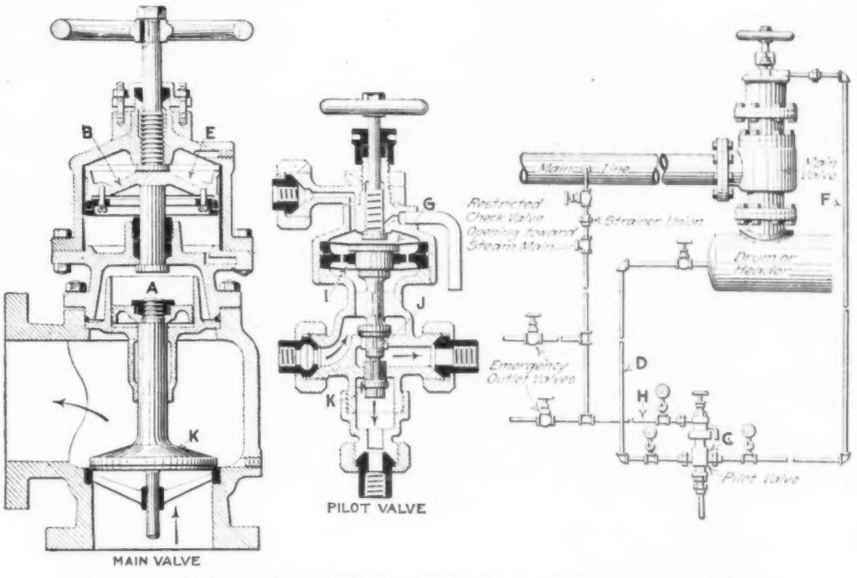


FIG. 20. FOSTER EMERGENCY NONRETURN VALVE, PILOT VALVE AND MANNER OF PIPING

the boiler pressure on one side; the other side is connected to the steam pipe. The valve is set to a predetermined difference in the pressure, and should a break occur and the pressure in the steam main or header fall below a fixed difference, the pilot valve will operate and simultaneously close the emergency valve by cutting off the steam pressure from below the piston *A*. The boiler pressure above the piston then forces the disk *F* to its seat.

Foster Emergency Nonreturn Stop Valve

The type of valve shown in Fig. 20 is designed to prevent the steam from a boiler from blowing out of a ruptured pipe line in case of accident and filling the room in which the accident happens. With such a valve in a line between the boiler and the header, there is no need of trying to shut a stop valve with the boiler room full of steam caused by a burst fitting, badly leaking joint or by some other serious accident.

The lower portion of the valve is designed the same as a nonreturn valve and operates as such. In addition to the valve disk and dashpot, a second chamber is placed above the dashpot *A*, in which is a piston *B*, which is actuated by steam at boiler pressure in case of a pipe-line failure.

The action of the piston *B* is controlled by a pilot valve *C*. The pilot valve is placed at any convenient point, and a small pipe line *D* is connected to the boiler or steam header and from the pilot valve to the chamber *E* of the main valve by the pipe *F*. The diaphragm chamber *G* of the pilot valve is also connected to the header or main steam line at a point beyond the outlet of the main valve, by the pipe *H*.

Whenever the pressure in the steam line falls abruptly, as when a rupture occurs, a corresponding drop of pressure takes place in the upper diaphragm chamber *G* of the pilot valve. This allows the boiler pressure acting on the under side of the diaphragm *I* to open the valve *J*, which, under normal conditions, is closed, and bring the valve disk *K* to its seat. The full boiler pressure then flows through the main port of the pilot valve into the chamber *E* of the main valve and acts upon the piston *B*. As the area of *B* is greater than that of the main valve, the downward movement of the piston will force the valve to its seat and prevent further flow of steam to the main.

Strong Nonreturn Stop Valves

A compact form of nonreturn stop valve is shown in Fig. 21. It can be placed in the pipe line in either a

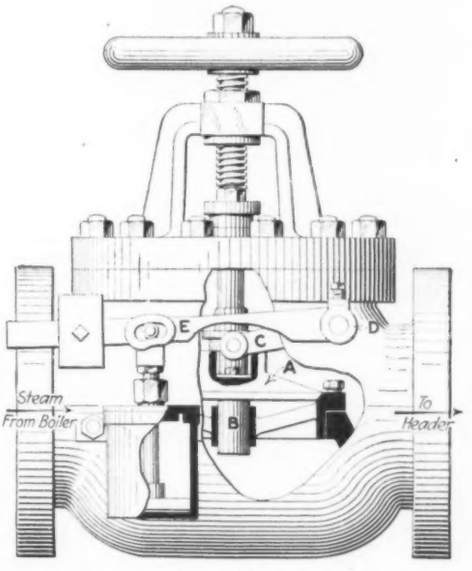


FIG. 21. STRONG NONRETURN VALVE

vertical or a horizontal position. It is of the outside dashpot, weight and lever type.

The disk *A* is guided to its seat by the end of the spindle *B*. The yoke *C* is secured to the upper part of the disk by a pin and is securely attached at the other

end to the lever stem *D*, which passes through a stuffing-box and supports the weight lever *E*. The dashpot plunger rod has a cam-like joint to prevent binding where it is pinned to the weight arm. The disk *A* is held in balance by the weight. Slamming and chattering are prevented by the dashpot. The valve stem, which can be used to close

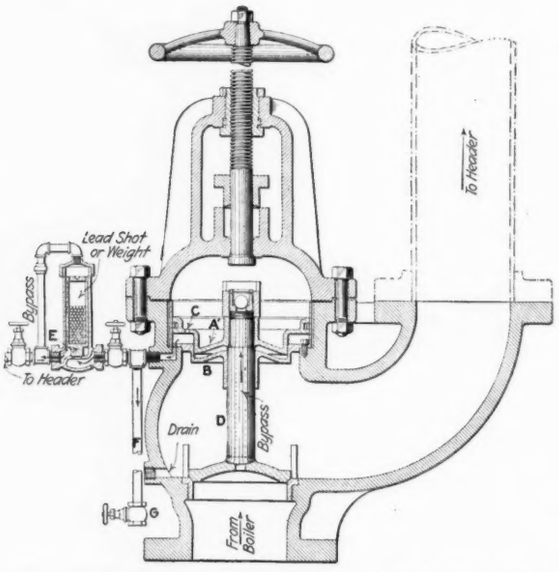


FIG. 22. GOLDEN-ANDERSON DOUBLE-CUSHION TRIPLE-ACTING NONRETURN VALVE

the valve by hand, has a disk that seats at the extreme travel of the stem and permits of packing the stem while the valve is under pressure.

Golden-Anderson Double-Cushion Triple-Acting Nonreturn Valve

Fig. 22 shows a valve for preventing an abnormal flow of steam either way—from a boiler to the steam main or from the main to the boiler. In the latter case the main valve is controlled by a pilot valve.

The movement of the main valve is cushioned by a dashpot *A* that occupies the full area of the upper portion of the body. The piston is attached to the spindle *D*, on the lower end of which is the valve disk. As in other valves with the nonreturn feature, the boiler pressure exerts its force against the under side of the disk, and when this pressure is less by about 8 lb. than that in the steam main, the valve disk is forced to its seat. As an emergency valve a pilot valve is required, and when it acts, steam is prevented from entering the steam main. The bypass *C* admits steam at boiler pressure to both sides of the dashpot piston *A* and balances it. The steam connection from the main steam line to the pilot valve holds the valve *E* closed because of the large area exposed to pressure above it. There is also a steam connection between the two dashpots leading to the pilot valve. If a rupture occurs in the steam line, the pressure is removed from the top of the pilot valve *E*, which allows it to open and exhaust the pressure from between the dashpots *A* and *B* of the main valve. As the full boiler pressure is always above the dashpot *A*, the main valve will close. The pilot valve can be adjusted for any variation of pressure by adding or removing weight from the hollow piston for greater or less variation between the boiler and the header pressure.

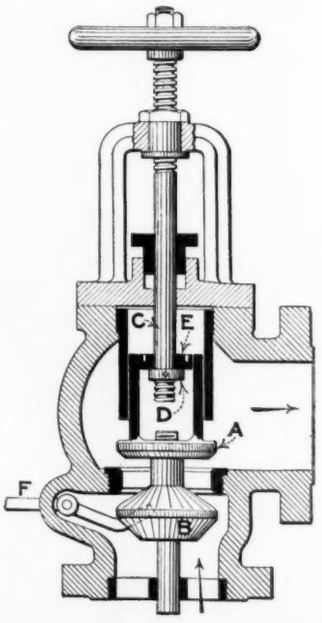


FIG. 24. ACTON TRIPLE-DUTY VALVE

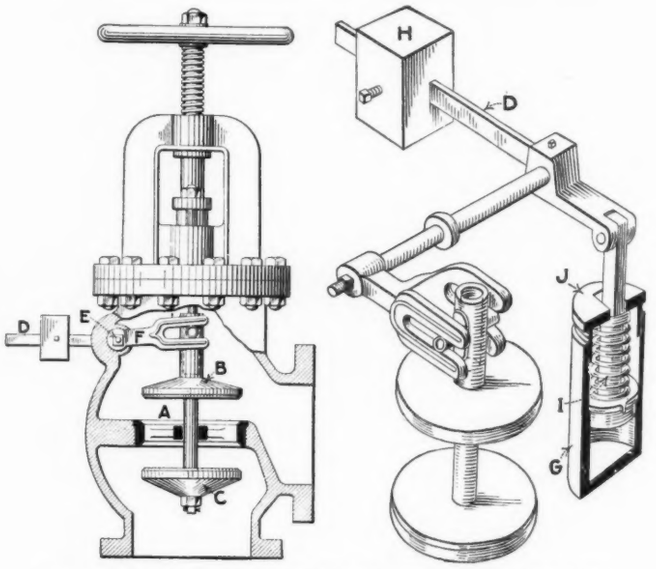


FIG. 23. LAGONDA AUTOMATIC CUTOFF VALVE AND DETAIL OF PARTS

The branch pipe *F* is for testing the valve while in service by opening the valve *G*. This relieves the chamber below the dashpot A, and the main valve will close and remain so until the test valve is closed, when the main valve will open. This feature enables the operator to test the action of the valve and avoids the necessity of going to the top of the boiler to close and open the main valve by the handwheel.

Lagonda Automatic Cutoff Valve

Another valve designed to close automatically should an abnormal flow of steam occur in either direction is shown in Fig. 23. It can also be used as a stop valve. This valve consists of a double-faced seat *A* and an upper and a lower disk *B* and *C*. The disks are balanced by an outside lever *D* and dashpot *G*. The lever is keyed to the stem *E*, which carries the fork *F*, which connects with the valve-disk stem. By means of the dashpot *G*, the lever and the weight *H*, the valve can be set to take care of any ordinary overload.

The spring *I* in the dashpot is adjusted for tension by a cap *J*, and the tension of the spring, which is counterbalanced by the weight *H*, prevents pulsations of the valve disks.

If a boiler tube should rupture or a steam line break, the excessive flow of steam would force either one or the other disk to its seat, shutting off the flow of steam

through the valve. When the valve operates, the tension of the dashpot spring is overcome by the pressure of the steam acting upon the valve disk, which closes against the seat in the direction of the steam flow.

Acton Triple-Duty Stop and Check Valve

The double-acting valve, Fig. 24, is of the angle design. It is made with a double-faced seat. The valve disks *A* and *B* are carried central to the valve seat by

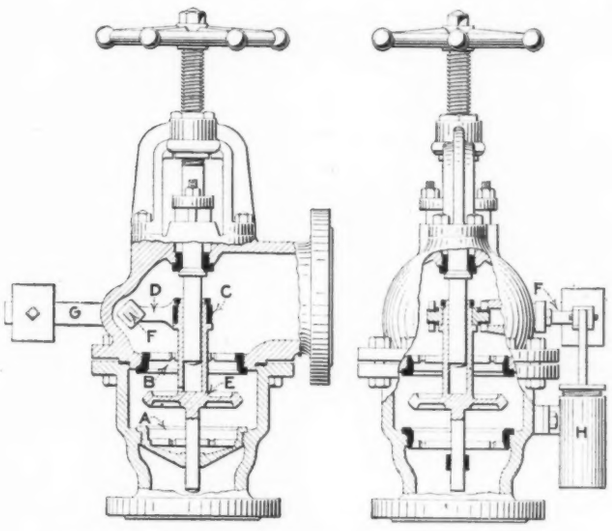


FIG. 25. POWELL DOUBLE-SEAT STOP VALVE

the long-bearing dashpot on the upper side and the extending stem below the bottom disk. With a greatly reduced pressure on the outlet side of the valve, the bottom disk is forced to its seat. If the inlet pressure drops materially, the higher pressure in the header or steam main will force the top disk to its seat.

The valve stem *C* has on its lower end a ring that engages with the plug in the top of the dashpot piston when the valve stem is screwed out, which brings the disk *B* to its seat. Screwing down the stem will force the disk *A* to its seat. When the valve is in service, its stem is placed in mid-position, which point is indicated by a groove on the stem and a pointer on the bonnet of the valve (not shown).

The valve has an auxiliary means of closing it against either the inlet or discharge pressure. This is accomplished by the lever *F*, which is attached to a stem that emerges from the valve body through a stuffing-box. From the stem an arm extends to a slotted space in the lower valve disk. When it is desired to close the valve quickly, the lever *F* is pulled in either direction by a cord or other convenient means, which closes the valve.

Powell Double Stop Valve

The valve illustrated in Fig. 25 is another designed to close when a serious drop in pressure occurs on either side of it.

The lower valve seat *A* is screwed into the body of the valve, the upper one *B* into the valve bonnet. On the valve spindle is a collar *C* held in place by a fork *D*. This arrangement allows the disk *E* free movement for turning. To the outside end of the balancing lever *F* is fitted the weight lever *G*, one end of which is connected to the plunger of the dashpot *H*, which is filled with oil. The dashpot prevents the disk from pounding and chattering, and the weight on the weight arm is for balancing the weight of the valve disk. The valve can be seated by the handwheel and valve stem when desired.

In action the disk will close against the seat *A* if the pressure in the boiler drops materially and against the seat *B* if the header or pipe-line pressure falls much below that in the boiler. This is accomplished by the double-faced disk *E*.

Crane-Erwood Double-Acting Valve

Another double-acting nonreturn and emergency cutout valve is shown in Fig. 26, which illustrates the valve disks in a normal position.

If a tube blows out or trouble occurs in the line between the valve and the boiler, the disk *A* will close against the inlet and cut out the boiler from the header. The disk will remain closed until the steam pressure in the boiler

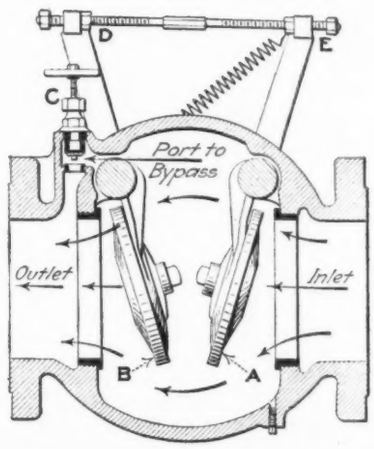


FIG. 26. CRANE-ERWOOD DOUBLE-ACTING VALVE

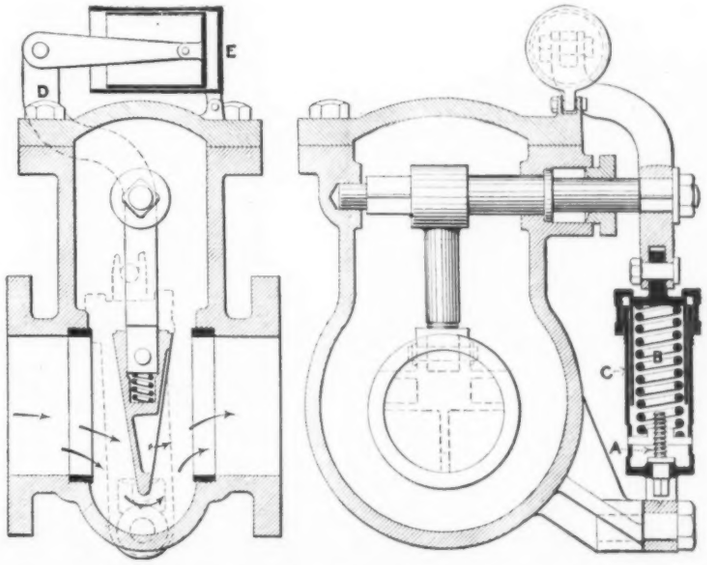


FIG. 27. GOLDEN-ANDERSON DOUBLE-DUTY CUTOFF VALVE, SIDE AND END VIEW

is brought up to that in the main. This action will also indicate that a boiler is not doing its proportion of work, because as soon as the pressure in the boiler drops below that in the main, the disk seats.

The double-acting feature is comprised in the disk *B*, which will close automatically if a section of the main header or distributing lines fails, such as the bursting of a fitting or valve. This valve also acts as a safeguard to the pipe line should a careless operator open a large valve too rapidly.

After the valve has automatically closed because of the sudden rush of steam, it will automatically open when the pressure in the header or main steam pipe equals that in the boiler. This action is brought about through the medium of the bypass valve *C*, which is open except when it becomes necessary to cut out the header on account of trouble.

After the valve has closed because of a ruptured steam line and upon the completion of repairs, it can again be brought into operation by opening the bypass valve *C* to allow the pressure to equalize on both sides of the disks.

The position of the disks is indicated by the levers *D* and *E* on the outside of the valve. The separating link is for adjusting the position of the disks for the load to be carried. Shortening the link decreases the volume of steam, and lengthening the link increases the volume passing through the valve. A dashpot connected to one of the arms prevents the valve disks from closing with violence.

Golden-Anderson Double-Duty Cutoff Valve

The valve in Fig. 27 also performs the double duty of protecting the boiler and the pipe line. The valve spindle and disk swings to the seat on the side having the lowest steam pressure, as it depends on the velocity of the steam to carry the disk to either seat.

The valve is adjusted by the screw *A*, which compresses the spring *B*. This exerts a pressure on the toggle joint and the sleeve *C* that holds the valve spindle and arm *D* in a central position, and also prevents the valve from closing under normal pressure against the outlet connecting with the steam header.

The valve, in closing against the outlet side, always works against the tension of the spring *B*. But the spring offers no resistance to the closing against the inlet or boiler side of the valve. The action of the valve is cushioned by the dashpot *E*. The arrows show the path of the stream through the valve.

Lagonda Multiple Filter and Grease Extractor

The term "multiple filtration" has been applied by the Lagonda Manufacturing Co. of Springfield, Ohio, to its latest product, a double-unit filter and grease extractor, because the filtering element consists of a coil of Terry cloth, the several plies of which are separated by a flexible wire mat and wound, as shown in Fig. 2, upon a spool with a hollow cylindrical perforated core.

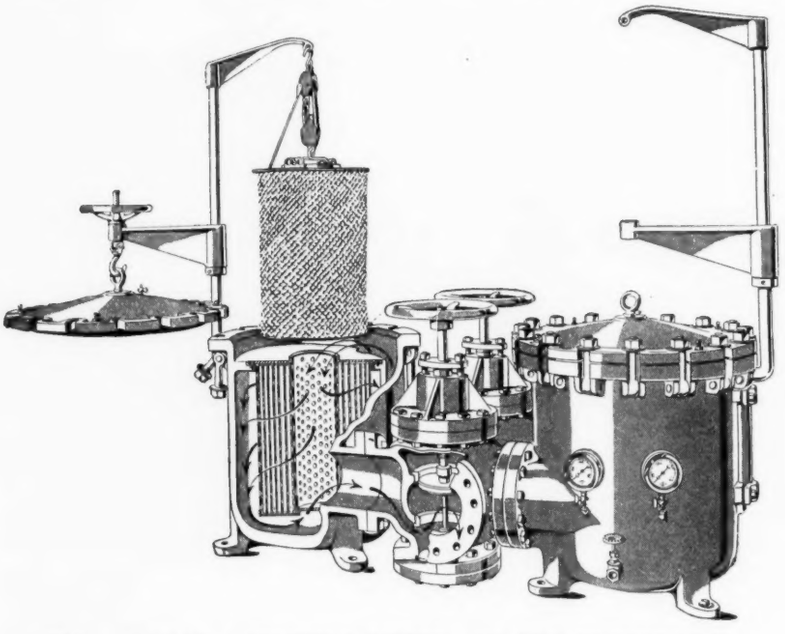


FIG. 1. LAGONDA MULTIPLE FILTER AND GREASE EXTRACTOR

FIG. 2. REEL FOR FILTER SPOOL

A special winding device for the easy and even winding of the filter cloth and mesh on the spool was described in the issue of Nov. 9. The Terry cloth is in one long strip, and for ordinary work from six to eight plies of the filtering material are wound upon the spool. The spool is inserted in the filter chamber, as shown in Fig. 1. The water to be filtered, entering through the perforated core of the spool, passes through the several layers of filtering cloth into the chamber surrounding it, thus giving "multiple filtration." Hinged slot bolts are used for the covers. The davits are mounted in ball bearings, making it easy to handle both the filter spools and covers, and the filtering spool may be allowed to hang suspended above its chamber until thoroughly drained, avoiding mussiness in its removal and handling.

Under ordinary circumstances the filter cloth need be removed and cleaned not oftener than every 10 or 15 days. The necessity for cleaning is indicated by the difference in pressures on the inlet and outlet sides of the filtering material, which pressures are indicated by

the gages shown, the difference in their indications increasing as the filtering material becomes clogged, and cleaning is advised when the difference reaches ten pounds.

The Lagonda filter consists of two such complete units, connected by valve passages into a compact self-contained unit, as shown in Fig. 1. An extra spool with its filtering material is furnished, by which a fouled one may be immediately replaced and both chambers kept in operation, if necessary, although normally one chamber will furnish the rated capacity, leaving the other ready to be cut in for use when it becomes necessary to change the spools or to be cut in in parallel with the other in times of excessive demand. Each cylinder is provided with a flush-cock, which may be connected to the sewer and used for washing out the chamber.

Conway Building Power Plant--II

By Thomas Wilson

SYNOPSIS—The boiler room, coal and ash handling, steam piping, complete equipment of instruments and the record system are described.

In the boiler room six 250-hp. water-tube boilers have been installed (Fig. 8). The total of 1,500 b.hp. bears a ratio to the 1,200 kw. of generating capacity of 1 to 0.75. The boilers have chain-grate stokers, each having an area of 60 sq.ft., which to the 2,500 sq.ft. of boiler-heating surface bears a ratio of 1 to approximately 42.

The bottom of the front header is set 30 in. above the floor. The boilers are horizontally baffled, the lower row of tubes being covered with split C tile. The furnaces project 3 ft. 10 in. from the boiler fronts. Three of them have ventilated arches and three flat arches, the gate opening for the latter being 15 in. and the distance from the grate to the inner end of the arch, 31 in. Over the bridge-wall the area for the gases is 18.68 sq.ft.; at the rear entrance to the tubes between the tile and the back header, the area is 11.76 sq.ft.; at the opening through the top baffle, 9.38 sq.ft. and in the uptake around the rear of the boiler drum the clear area is 16 sq.ft.

Area of Steel Breeching and Chimney

The steel breeching, which is lined with 1-in. insulation, is rectangular and of tapering section. It passes over the rear of the boilers and makes one right-angle turn into a steel stack, which is oval in section. At the stack the breeching area is 50 sq.ft. This bears a ratio of 5 to 4 to the 40 sq.ft. area of the stack. The height of the stack is 310 ft. From the foregoing areas it may be observed that for every 1,000 sq.ft. of boiler-heating surface there are 24 sq.ft. of connected grate surface, 3.33 sq.ft. of breeching area and 2.66 sq.ft. of stack area. The main damper in the breeching is controlled by a damper regulator, and this also controls the stoker engines. Arrangements are made, however, so that the damper control may be transferred to any individual boiler. In all there are four stoker engines belted to the stoker shaft, which is so coupled that any one of the stokers may be cut out and those on either side operated by using two of the engines.

Coal may be brought to the plant by wagon or through the underground freight tunnel. From the wagons it is dumped into a 20-ton bunker through coal holes in the alley. Through chutes at the bottom of this bunker the coal may be delivered to a continuous bucket conveyor, which runs over head and discharges into individual steel bunkers opposite each boiler. The discharge of coal from the main bunker is controlled by gates operated by chains from the boiler-room floor.

When the coal is delivered in tunnel cars, it is dumped into a track hopper and elevated by a bucket conveyor to the main conveyor, which will discharge it to the individual bunkers previously mentioned or to the main bunker, as desired. A track scale with the weighing mechanism on the boiler-room floor registers the weight of the coal cars as they are brought in and the empty cars as they are going out. Under each individual steel bunker, stationary scales weigh the coal on its way to the stoker hoppers. The weighing beams are mounted on the boiler-room wall about 5 ft. above the floor. Illinois and Indiana screenings are used as fuel.

Mechanical Drag for Handling Ashes

Under each stoker is a chain ash-drag operated through an eccentric and ratchet from the stoker shaft. The ashes fall into a hopper which discharges directly below into the tunnel cars, the gate at the bottom of this hopper being controlled by a chain from the boiler-room floor. The ashes are weighed by the track scale used to weigh the coal.

Feed water for the boilers may be drawn from three different lines, two of which are connected to the feed pumps and may be used interchangeably, and the other to the city mains. At each boiler connections are brought down from the two pump-supply mains to within easy reach of the floor, and four valves in parallel are interposed between this line and its continuation leading into the boiler. Two of the valves are ½ in. and the other two ¾ in. diameter, so that the feed may be easily regulated by valves which are fully opened in each case. In addition there is a line running back of the boilers for washing, and another line in front which may be supplied with water from the house tanks or with compressed air for operating a turbine tube cleaner. The two feed pumps are of the duplex outside-packed pot-valve type, each capable of handling 35,000 lb. of water per hour. They are so cross-connected that they can be used singly or in parallel, on any number of boilers from one to six and on either line. Besides the usual heater connections, the pumps may also draw from the city water mains.

Two feed-water heaters of the open-receiver type each capable of heating 48,000 lb. of water per hour from 45 to 210 deg. F., are installed. The heaters are connected in parallel and may be used singly or together. Returns from the heating system are collected in an

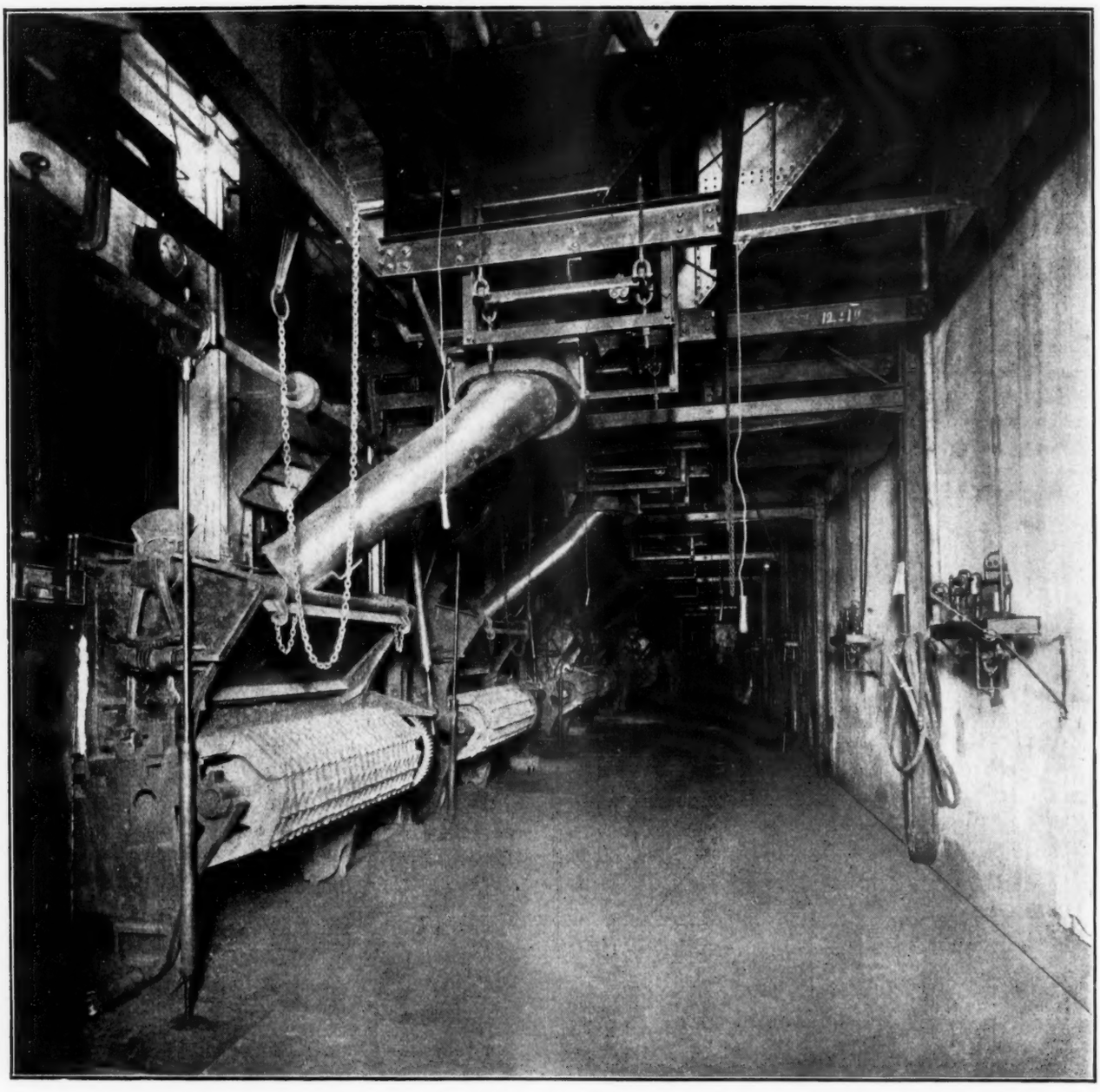


FIG. 8. BOILER ROOM OF CONWAY BUILDING, SHOWING COAL BUNKER AND STOKERS

8-in. header, from which they are pumped into a receiving tank and thence flow by gravity through a dumping meter to the feed-water heaters. Makeup water from the city mains is metered before it enters the heater. In each pump-supply line to the boilers is a venturi meter, and as the returns from the heating system are measured, it is possible to divide proportionately the total steam generated into that required for heating and the balance to the generating plant.

The general layout of the piping is shown in Fig. 9. From each boiler 8-in. pipes curve toward the front of the boiler into the top of a 12-in. header. At the center a valve divides the header, and including one boiler on either side of this valve, connections lead to an 8-in. auxiliary header which supplies the pumps. An 8-in. loop running back over the breeching is taken off the main header, and from this loop connections lead to the generating units. To the 600-, 400 and 200-kw. units, the steam-supply pipes are 8, 8 and 6 in. in diameter respectively, notwithstanding that a receiver-separator 3½ times the volume of the cylinder has been provided in each case. At normal load and assuming continuous flow of the steam, the velocity would be 2,400, 1,600 and 1,100 ft. per min. respectively, which in each case is considerably lower than standard practice would prescribe.

The exhaust line from each engine contains a valve controlled from a floor stand. Exhaust from the three engines is collected in a 20-in. main running in a tunnel under the engine-room floor and entering the boiler room, where it divides and distributes the steam between the expansion tank and the feed-water heaters. An additional passage is provided for the exhaust of the 200-kw. unit, so that the main exhaust header may be cut out for repairs on Sundays, holidays or at any time the load will permit.

In draining the various headers the traps have been concentrated into large units. All condensation in the boiler room is collected in one trap, a duplicate trap be-

ing provided to act in case of emergency. The three receivers on the engine supply lines are also cared for by a duplicate set of traps. The condensation from the 20-in. exhaust line is trapped into the ejector pit, but if this apparatus should become inoperative and the condensation back up in the drip line, a duplicate set of traps at the opposite end will take care of it and discharge it into an open tank. This at once denotes that the trap discharging into the ejector pit is inoperative and needs attention.

A feature of the plant is the number of gages and recording instruments. The engineer is never at a loss to know the operating conditions in any part of the plant, and the recording instruments show what part of the total service is delivered to each department. In the engine room an unusually complete gage board (Fig. 10) is mounted in the wall. All of the connections come in at the back of the board in the boiler room, and they are provided with drains and cocks, so that any gage can be tested without being removed from the board. On this board are 13 gages and an 8-day clock. Seven are high pressure steam gages, one for each boiler and one for the main steam header. Besides there is a gage to measure the pressure of the city water-supply, a back-pressure gage on the exhaust header, a combination vacuum and pressure gage on the returns of the heating system, an air-pressure gage on the temperature-regulating system, another air pressure gage on the air receiver for the ejector system, and finally a differential gage measuring the draft at the base of the stack. Near the gage board is an indicator showing the level of oil in the storage tank of the gravity system for the main generating units. Then for the compound engine there is an independent gage panel on which are three gages to show the initial steam pressure, the receiver pressure and the back pressure. Near this unit there is also a continuous smoke recorder under a glass bell mounted on a pedestal.

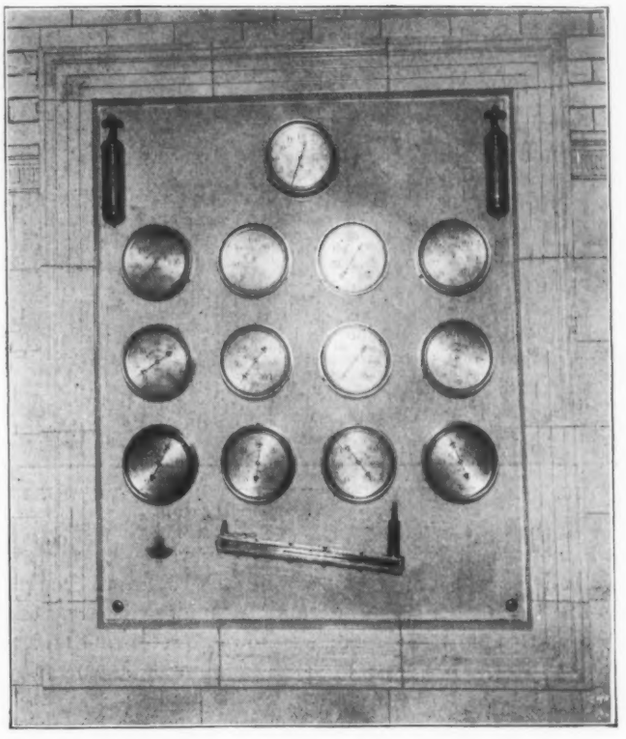


FIG. 10. GAGE PANEL IN ENGINE ROOM

The recording instruments are in the office (Fig. 11). The two venturi meters of the indicating, integrating and recording type on the boiler feed-water lines are located here, and on a special panel are nine additional record-

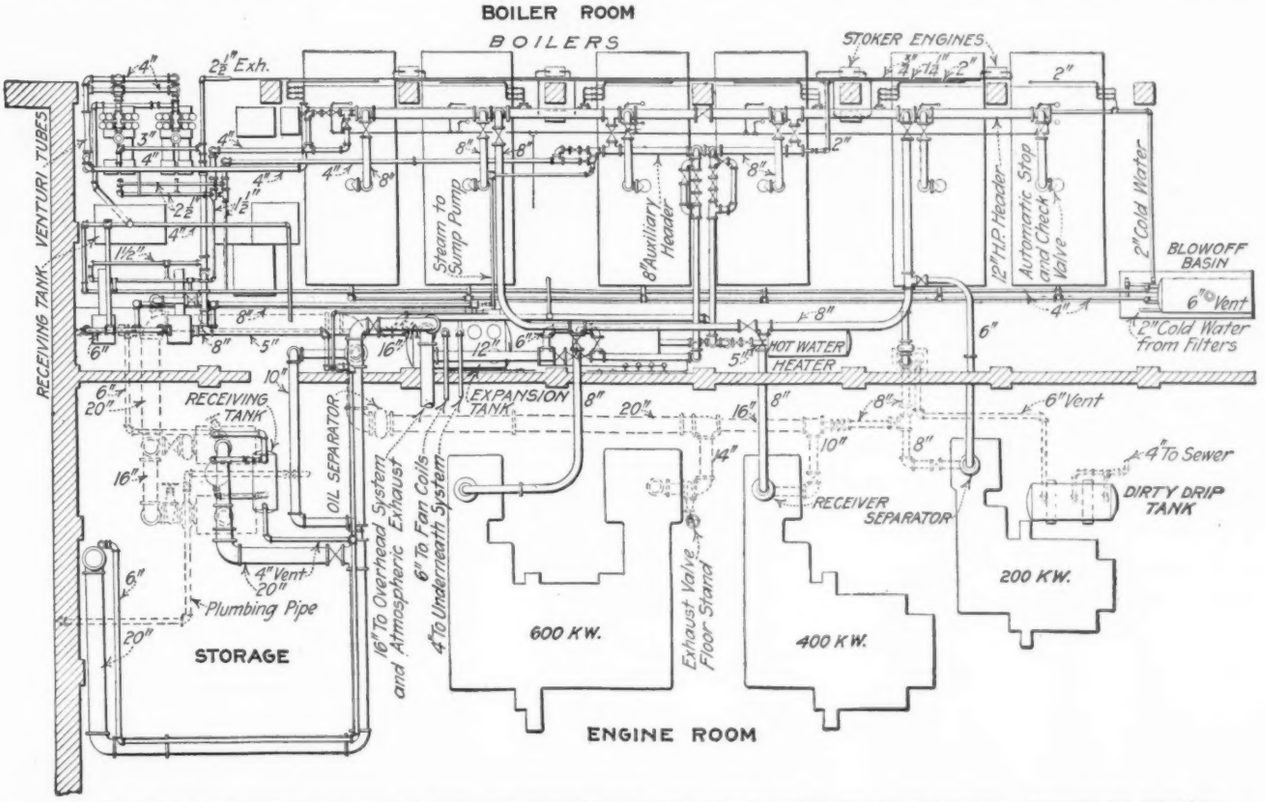


FIG. 9. PLAN OF THE POWER PLANT, SHOWING THE ARRANGEMENT OF THE UNITS AND MAIN PIPING

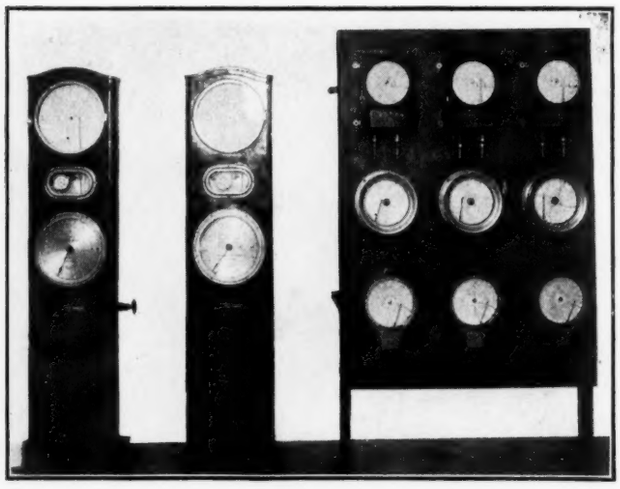


FIG. 11. RECORDING INSTRUMENTS AND VENTURI METERS IN OFFICE

ing meters. Three are boiler efficiency meters for the six boilers. Two connections from each boiler are brought to the back of the board and may be connected to any one of the three meters. In addition to these recording meters there is an efficiency meter on each boiler. The panel also contains three pressure-recording meters—one a combination pressure and vacuum instrument on the expansion tank, one a vacuum meter on the heating system, and the third an instrument recording the pressure on the main steam header. The remaining three instruments are recording thermometers—one on the domestic hot-water supply, one on the feed-water heater and one to record the outdoor temperature. With this array of instruments it is possible at any minute to determine the operating conditions in the plant.

With so many instruments, both indicating and recording, it was not difficult to originate a complete system of records accurately dividing the cost between the various departments. All electrical instruments and water meters are read at the end of each watch, and these readings, with the coal weights, are turned in to the chief engineer. From these data the evaporation of water per pound of coal and the cost of coal per 1,000 lb. of steam are figured daily, so that any dropping off in the efficiency will be detected at once. This is done for a month, and the data are then entered on a large monthly report sheet. Besides the weights of coal and water, including the returns from the heating system and the makeup, there are columns for the total kilowatt-hours generated, the evaporation per pound of coal, pounds of coal per kilowatt-hour, boiler horsepower-hours, feed-water temperature, cost of coal, B.t.u. per pound of coal, percentage of ash, cost of water, cost of removing ashes, cost of labor, coal cost per 1,000 lb. of steam and total cost per 1,000 lb. of steam.

In addition to the operating records there is a complete system of orders for new work requiring revision. The forms are all the same except that each designates the particular department, such as plumbing, electrical, heating, elevator, etc., for which the work is done. In this way the costs may be separated and properly charged.

PRINCIPAL EQUIPMENT OF CONWAY BUILDING POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
6	Boilers	Water-tube	250-hp	Generating steam	160 lb. pressure, stokers, natural draft	Oil City Boiler Works
6	Stokers	Chain-grate	60 sq.ft	Serve boilers		Green Engineering Co.
1	Conveyor	Continuous-bucket	40 tons per hr.	Raise coal to bunkers	Driven by 15-hp. Western Electric motor	Alvey-Ferguson Co.
1	Conveyor	Bucket	40 tons per hr.	Coal from tunnel to main conveyor	Driven by 5-hp. Western Electric motor	Alvey-Ferguson Co.
6	Scales	Beam		Weigh coal to boilers		Strait Scale Co.
1	Scale	Track		Weigh coal and ashes in tunnel		Fairbanks, Morse & Co.
6	Bunkers	Steel	2½ tons	Immediate supply to each boiler		Alvey-Ferguson Co.
6	Meters	Boiler-efficiency		Draft drop through boiler		W. A. Bloneck & Co.
1	Damper regulator			Control main damper		Spencer Regulator Co.
2	Pumps	Duplex	12x7½x10-in.	Boiler feed	150 lb. steam, 20th Century governors	Henry R. Worthington
2	Pumps	Vacuum	10x16x18-in.	Heating system	150 lb. steam	Blake & Knowles
2	Pumps	Triplex	7x8-in.	House pumps	Driven by 20-hp. Western Electric motors	Goulds Mfg. Co.
3	Engines	Corliss	16x36; 24x42; 24x40x 42-in.	Main generating units	100 and 125 r.p.m. non-condensing	C. & G. Cooper Co.
3	Generators	2-wire, direct-current	200, 400 and 600-kw.	Main generating units	230-volt, direct-connected	Crocker-Wheeler Co.
2	Balancers		100-amp.	Balance 3-wire distribution		Crocker-Wheeler Co.
3	Engine stops	Electrical		Prevent overspeed on engines		Locke Regulator Co.
2	Heaters	Open	48,000 lb. per hr.	Heat boiler-feed water	Exhaust steam	Jno. E. Angells & Co.
7	Traps	Float		High- and low-pressure drips		Julian d'Este Co.
2	Heaters	Closed		House service	Exhaust steam	Berryman Feed Water Heater & Purifier Co.
7	Fans	Sirocco		Ventilation	Driven by General Electric motors	American Blower Co.
1	Air washer	Acme	30,000 cu.ft. per min.	Air for entrances		Iroquois Engineering Co.
16	Elevators	1 to 1 gearless-traction	2,750 lb. at 500 ft. per min.	Passenger	Driven by 35-hp. motors	Otis Elevator Co.
1	Elevator	Double-worm-gear traction	3,000 to 12,000 lb.	Freight	Driven by 40-hp. motor	Otis Elevator Co.
1	Oiling system	Gravity	100-200 gal. per hr.	For Corliss engines		Richardson-Phenix Co.
3	Lubricators	Force-feed		Engine cylinders		Richardson-Phenix Co.
4	Lubricators	Force-feed		Steam pumps		Hills-McCanna Co.
12	Circuit-breakers	I. T. E. "Directite"		Feeder panels	220 volts	The Cutter Co.
3	Circuit-breakers	Remote-control		Generator panels	220 volts	The Cutter Co.
4	Watt-hour meters			Feeder circuits		Duncan Electric Mfg. Co.
2	Recording instruments	Continuous record		Feeder board	One ammeter and one voltmeter	The Bristol Co.
2	Voltmeters			Bench board		Weston Elec. Ins. Co.
3	Ammeters			Bench board		Weston Elec. Ins. Co.
3	Rheostats	Motor-operated		Feeder board		The Cutter Co.
13	Gages	Indicating		Steam, water and air		Jas. P. Marsh & Co.
1	Draft gage	Differential		Draft at base of stack		Lewis M. Ellison
3	Gages	Indicating		Compound-engine panel		Crosby Steam Gage & Valve Co.
1	Meter	Dumping		Returns from heating system		Alberger Pump & Condenser Co.
1	Smoke recorder	Continuous		Smoke in stack		The Hamler-Eddy Smoke Recorder Co.
2	Meters	Venturi		Feed-pump lines		Builders Iron Foundry
3	Efficiency meters	Recording		Boiler-draft drop		W. A. Bloneck & Co.
3	Pressure gages	Recording		Exhaust and live steam		Crosby Steam Gage & Valve Co.
3	Thermometers	Recording		Domestic and feed-water and air temp.		The Bristol Co.
6	Gages	Indicating		Boiler pressure		American Steam Gage & Valve Mfg. Co.
2	Air compressors	Single-stage	12x8-in.	For ejectors and air on heat reg.	Driven by 15-hp. Western Electric motors	(Clayton) International Steam Pump Co.
1	Air compressor	Locomotive-type	11x11x12-in.	For high-pressure work		Westinghouse Air Brake

In a room-reference book every room in the building is credited with everything going into it and the date on which it is put there. Each room has a separate page, so that it is easy to determine just what the room contains and the number of changes that have been made.

For the power plant there is a special trouble ticket on which the time of the worker is given and the material used in making any repair. At the end of the month a summation of these tickets gives the upkeep on the plant and itemizes the particular machines that needed repairs. From these data and the monthly operating sheet previously referred to, a report is issued to the owners of the building. This is properly classified under the various departments. At the end of the year a summation is made of the various items under operating expense and maintenance. Insurance and other items not previously included are added, and the total cost is obtained. As has been previously stated, a dumping meter measures all the returns from the heating system. Whatever proportion these returns bear to the total water fed to the boilers, that proportion of the total cost is charged to heating and the balance to the electrical department. This again may be split into the various services supplied by the electrical plant.

Graham, Burnham & Co. were the architects for the building, and C. A. Carpenter, of this company, designed the complete electrical system. The feeder board, bench board and generator panels were built by the Cuthbert Electrical Manufacturing Co. The Hanley Casey Co. installed the heating and ventilating equipment under the supervision of C. J. Lehn, chief engineer of the power plant.

Economic Limit of Feed-Water Heating Surface

By F. H. Rosencrants

SYNOPSIS—Treats of the problem of furnishing the plant with the most correct amount of feed-water heating surface for conditions of excess exhaust and of inadequate exhaust.

In proportioning the surface in closed feed-water heaters there are two sets of conditions which arise. In case the exhaust steam at atmospheric pressure which is available for heating feed water is less than necessary to heat the water to the maximum practicable temperature, the problem involved is to determine the minimum amount of heater surface to absorb the available heat. In case the steam available for heating is in excess of that necessary to heat the water to the maximum practicable temperature, the problem is not so simple, as it involves the determination of how much surface and to what corresponding temperature the water can economically be heated.

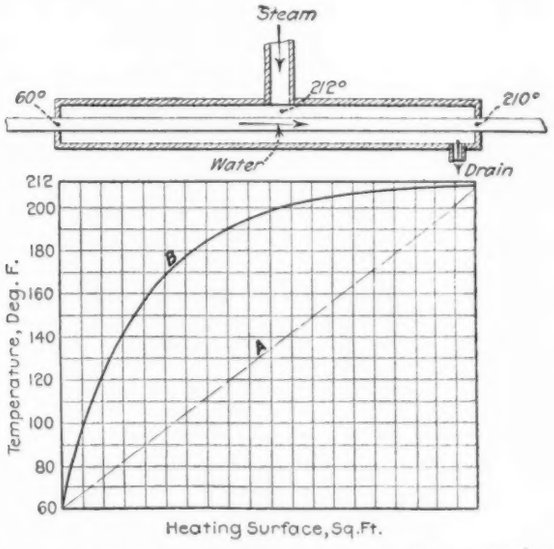


FIG. 1. TO SHOW THAT TEMPERATURE OF WATER DOES NOT INCREASE UNIFORMLY THROUGH HEATER

Adopting the following notation, let us determine whether or not the available steam is in excess of what it is possible to use.

G = Estimated or known amount of exhaust steam in pounds per hour at atmospheric pressure, with an assumed quality of 90 per cent;

W = Pounds of water to be heated per hour;

T_o = Temperature of water at entrance to heater;

T' = Temperature of water leaving heater;

L = Latent heat of steam at atmospheric pressure of 14.7 lb. = 970 B.t.u.;

h = Heat of the liquid at 14.7 lb. abs. = 180 B.t.u.

Heat given up by steam $= G(0.9L + h - (T' - 32))$ and heat absorbed by water $= W(T' - T_o)$. These two heat quantities must be equal, hence

$$G\,(0.9L + h - (T' - 32)) = W\,(T' - T_o)$$

Putting in the value of L and h and solving for T' gives

$$T' = \frac{W T_o + G\,1021}{W + G}$$

If this value of T' is greater than 212 deg. F., it shows that the available steam for heating is in excess of what it is possible to utilize. If it is less than 212 deg. F. by an amount in excess of three of four degrees, sufficient surface to absorb all the available heat will be a good investment and the problem, as stated in the first paragraph, is to determine the minimum amount of surface required.

Let

A = Required surface in square feet;

U = Coefficient of heat transmission, that is, the B.t.u. transmitted from steam to water per degree difference in temperature between steam and water per square foot of surface per hour;

d = Mean temperature difference between steam and water;

T_s = Temperature of steam = 212 deg. F.

Then

$$A\,U\,d = W\,(T' - T_o)$$

It is often incorrectly assumed that d is equal to $T_s - \frac{T' + T_o}{2}$, which is equivalent to assuming that the temperature of the water in passing through the heater increases uniformly. That this is not the case

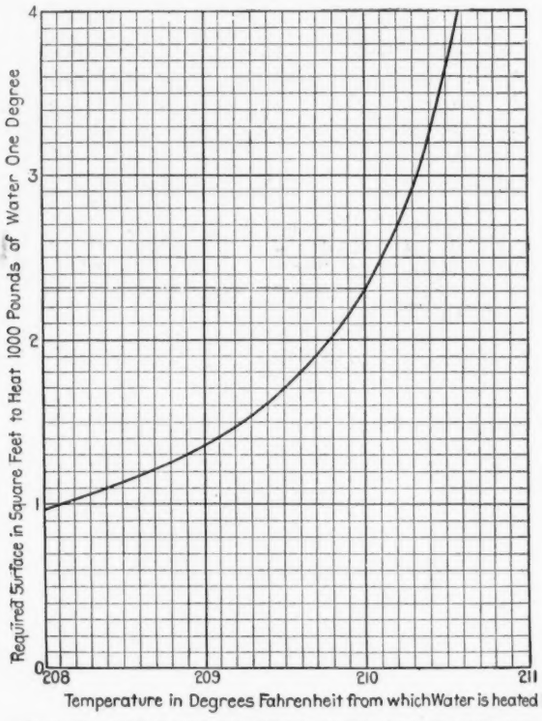


FIG. 3. SURFACE REQUIRED TO HEAT 1,000 LB. WATER 1 DEG. F. AT DIFFERENT TEMPERATURES

will be evident from a study of Fig. 1. The figure is self-explanatory and shows that at entrance to the heater, where the water is at 60 deg. F. and, hence, the temperature difference between steam and water large, the temperature rise will be rapid, and that as it progresses through the heater the rate of temperature rise decreases until, at exit, where the temperature difference is small, the rate of increase is correspondingly small. The curve B is plotted from calculated results, and the straight line A is drawn assuming the temperature of the water to increase uniformly in passing through the heater. It may be shown mathematically[1] that the true temperature difference is

$$d = \frac{T' - T_o}{\log_e \frac{T_1}{T_2}}$$

in which T_1 and T_2 are the initial and final temperature differences respectively, between steam and water. The equation expressing the relation between A, W, U and this value of d may be obtained by substituting this value in the equation cited and solving for A. This gives

$$A = \frac{W}{U} \log_e \frac{T_1}{T_2}$$

Solution of this equation, though not particularly difficult, is simplified by means of the chart shown in Fig. 2. The heavy dashed line indicates the solution in a particular case in which the amount of water to be heated is 42,000 lb. per hr. and the ratio of the initial to the final temperature difference between steam and water is 8. Beginning at the top of the diagram with 42,000 lb. of feed water, drop vertically down to the assumed coefficient of heat transmission of 300 (which, according to Gebhardt is a conservative figure) and proceed to the right to the value 8 of the ratio of the initial to the final temperature difference, and from there drop down to the desired area of 284 sq.ft.

When the supply of available steam for heating is in excess of what it is possible to use, it becomes a problem to determine how much surface, from the investor's viewpoint, it will be economical to install. It will be conceded that when the fixed charges on the cost of additional surface to raise the temperature an additional degree is equal to the cost of the fuel in a year to raise it one degree, the economic limit in surface is reached.

Statistics showed in a given case that the amount of feed water used in a year was 50,400,000 lb. and that the average evaporation per hour was 18,150 lb. The cost of heating this water 1 deg. F., with oil fuel based on

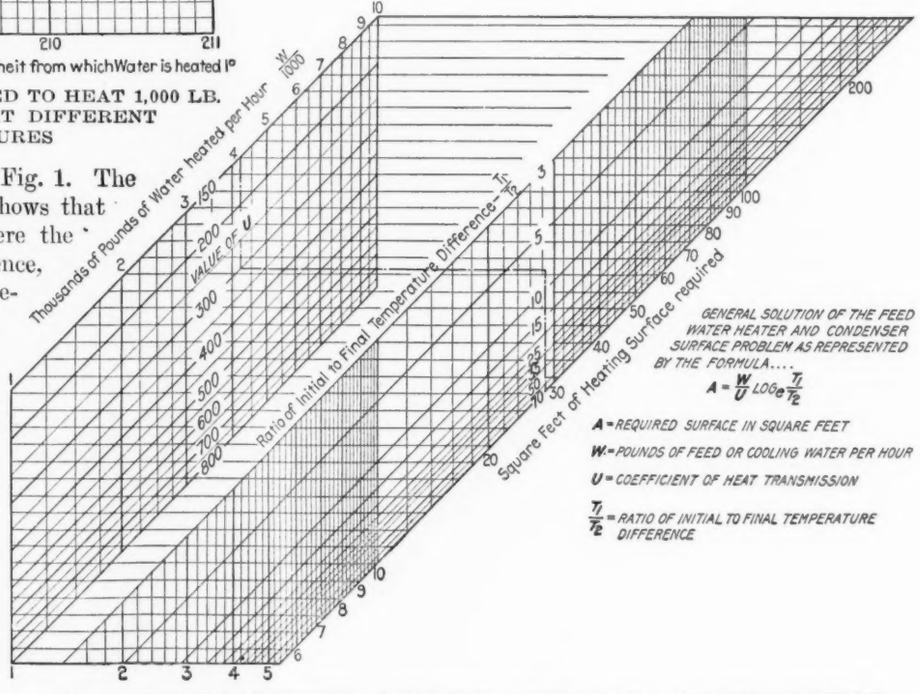

Thousands of Pounds of Water heated per Hour
W / 1000
VALUE OF U
Ratio of Initial to Final Temperature Difference
Square Feet of Heating Surface required
GENERAL SOLUTION OF THE FEED WATER HEATER AND CONDENSER SURFACE PROBLEM AS REPRESENTED BY THE FORMULA....
A = W/U LOGe T1/T2
A = REQUIRED SURFACE IN SQUARE FEET
W = POUNDS OF FEED OR COOLING WATER PER HOUR
U = COEFFICIENT OF HEAT TRANSMISSION
T1/T2 = RATIO OF INITIAL TO FINAL TEMPERATURE DIFFERENCE

FIG. 2. CHART FOR FINDING REQUIRED FEED-WATER HEATING SURFACE

oil at $1.10 per barrel and a boiler efficiency of 65 per cent., is $15.65 per year. This saving represents the fixed charges on the maximum allowable amount of surface to heat the water 1 deg. F. Assuming interest, depreciation, repairs, etc., equal to 15 per cent., the allowable cost will be $15.65 divided by $0.15, or $104.50.

[1] See Gebhardt's "Steam Power Plant Engineering."

The allowable cost per 1000 lb. per hr. will be $104.50 divided by $18.15, or $5.76. From proposals on feed-water heaters the cost per square foot of surface was found to be $2.48, laid down at the plant. Therefore, the allowable surface for heating 1,000 lb. of water per hr. 1 deg. F. equals 5.76 divided by 2.48, or 2.32 sq.ft. By referring to Fig. 3, it will be seen that 2.32 sq.ft. of surface will heat 1,000 lb. of water from 210 to 211 deg. F.

The initial temperature of the feed in the case under discussion was 165 deg. F., and from the chart the required surface to heat 18,150 lb. per hr. from 165 to 211 deg. F. is 230 sq.ft. The maximum flow of water through the heater was estimated to be 42,000 lb. By calculation, it is found that the amount of surface mentioned will heat this quantity of water to a temperature of 203 deg. F. It would heat it hotter than this because the coefficient of heat transmission increases considerably with the increase of velocity of water over the surface.

In conclusion, the writer wishes to point out that, though the accuracy with which the estimates and assumptions of annual water consumption, average flow and value of the coefficient of heat transmission may be taken does not warrant as refined an analysis as that given here, the calculations cited show that, based on the average flow of water through the heater, the temperature of the water may be economically raised well up toward the possible limit.

Flywheel Wreck in Ice Plant at Carthage, Mo.

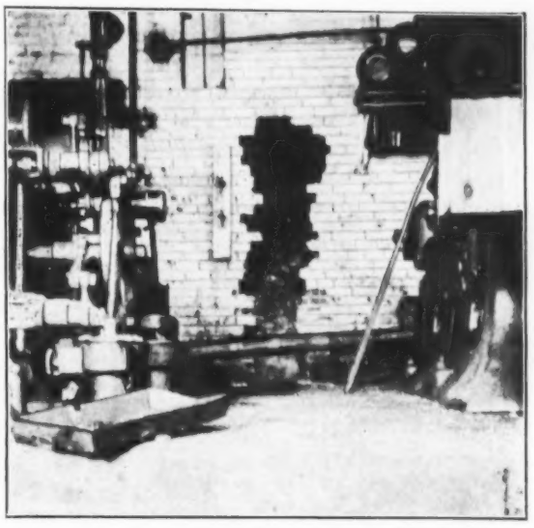
By W. J. Roth

On Dec. 8 at about 9 p.m., while the engineer was in the cold-storage room, a 10x24-in. Corliss engine at the plant of the Peoples Ice Co., Carthage, Mo., ran away, resulting in the bursting of a 7-ft. flywheel. Fortunately no one was injured, but the property damage was about $3,000 with no insurance. The engine was connected by a 6-in. shaft to a 7½-ton vertical compressor. The engine was badly wrecked, and the main bearing of the compressor and the crank were broken.

One large piece of the flywheel went vertically through the roof of the engine room, going through a steel pan on the roof and breaking the condenser pipes, and fell on the railroad track some distance away. Another piece went through the north engine-room wall, as shown in the illustration, also through the boiler setting, and landed on the furnace grates. About one-third of the wheel went through the engine-room wall and landed on top of the boilers nearest the wall, breaking the water-column connections and bending an I-beam supporting the boiler.

The governor was not equipped with a safety stop, and the indications were that the crank broke on the compressor side, releasing the load suddenly, and that the engine raced until the wheel went to pieces. A new crankpin had been fitted on the compressor a short time before, and the engineer stated that the pin drove hard until nearly up to the shoulders, when it suddenly went easier, no doubt cracking the crank. This is borne out by the fact that the compressor showed no signs of having raced. The collar on the governor stem was probably too low to prevent the valves from releasing and staying closed when the governor was at its highest position.

It required two days and nights to get the wreckage cleared away and repairs made so the other machines could be started. All the ammonia escaped through the



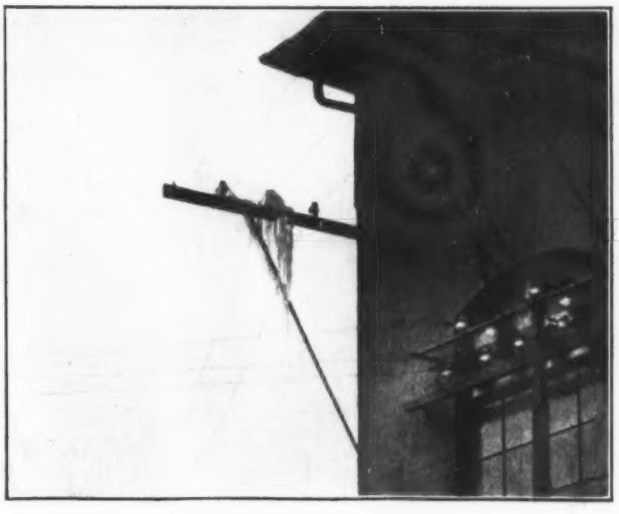
VIEW OF THE FLYWHEEL WRECK

broken connections. The wheel was made in two sections, bolted at hub and rim, had a solid rim 11x6 in. and ran at 70 to 80 r.p.m.

The engine can be seen at the left in the view, the compressor on the right and the crankshaft near the engine-room wall. The two boilers are on the opposite side of the wall.

Ice-Covered Insulators

It is sometimes surprising that trouble is not experienced more frequently from ice on high-tension line insulators. The accompanying illustration shows the ice-



INSULATORS BRIDGED WITH ICE

incased insulators on a 2,300-volt line where it enters the substation.

The insulator arm is attached to the building and is braced by an iron arm, which is also covered with ice. Although two insulators are bridged with ice, no trouble has been experienced because of it.

A Unique Navy Boiler

By Frank C. Perkins

The illustrations, Figs. 1 and 2, show the construction of a new safety water-tube boiler designed by the United States Navy to operate under 165 lb. pressure; a hydrostatic pressure of 500 lb. was successfully applied under test. The boiler is for use on small vessels.

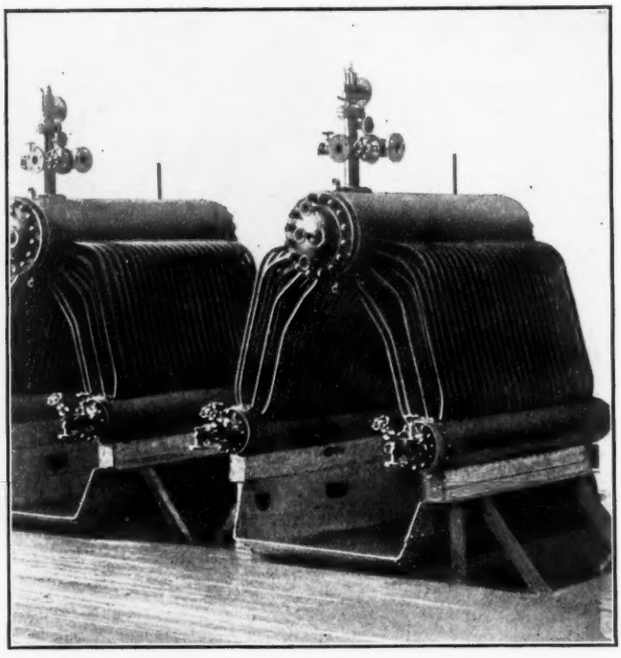


FIG. 1. SHOWING CONSTRUCTION OF SMALL NAVY BOILER

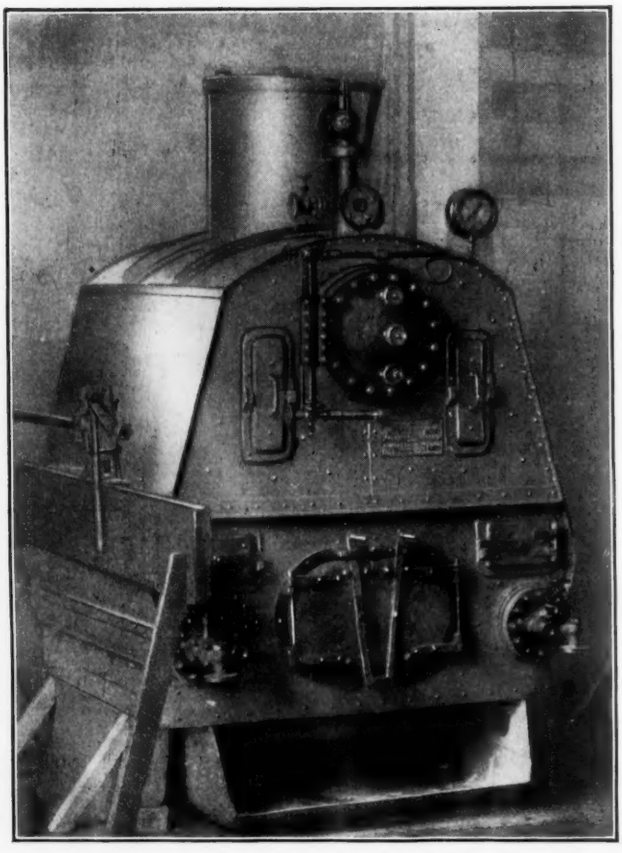


FIG. 2. THE BOILER INCLOSED IN ITS METAL CASING

These boilers have a length of casing of 4 ft. 3½ in. and a width of 4 ft. 4 in., the height including the ash pan being 5 ft. 6½ in., with a grate surface of 12.5 sq.ft. and a heating surface of 240 sq.ft. It is stated that the upper, or steam, drums are 15 in. outside diameter and made of lap-welded steel pipe ½ in. thick; the lower or mud drums are of the same material, 8⅝ in. outside diameter and $\frac{5}{16}$ in. thick. The tubes are 1 in. outside diameter, No. 12 b.w.g., of seamless drawn steel cold-bent to shape.

These boilers are provided with flanges, in accordance with the Bureau of Steam Engineering standard and weigh, dry, 3,800 lb. each.

JUST FOR FUN

Where Ignorance Is Bliss

A consulting engineer wrote to a prospective client who was contemplating constructing a transmission line a mile long to transmit current at 110 volts, offering his services in the design of the work. He received the following response:

"Replying to your letter of——— all the engineering consists of digging holes in the ground, putting poles in them, and stringing wires to the poles. It will hardly pay you to figure on the job, we think."

Very likely it would not pay the engineer but how about the other fellow?—Loren L. Hebberd, Milwaukee, Wis.

Well-Meant, but Not Practical

In a plant that had been idle for several years, new water columns and fittings were attached to the boilers prior to resuming operations. The boilers were of the horizontal-tubular type, two of them being larger than the third one. The work was let to a local pipe fitter and handyman, but when the engineer arrived he found the water column on the small boiler the same height as those on the larger boilers. On inquiry he found that the pipe fitter had leveled them for better appearance.—C. E. Kling, Philadelphia, Penn.

A Perfectly Good Term in Bad Company

A municipality having to extend the electric-supply mains called a meeting to consider estimates. The chief engineer had been called away, but the work was proceeded with in his absence. One of the items in the estimate was for "potential wires." A councilor asked, "What are potential wires?" No one knew. The clerk thought of consulting a dictionary. "Potential" was found and the meaning, "existing in possibility but not in reality," was decided to be the one applicable. That was the best they could do, so the council passed in the estimates —— dollars for "potential wires, or wires existing in possibility but not in reality."—H. Baron, Stettler, Alta.

DICTIONARY HELPED SOME

Editorials

The Value of Instruments

To operate a plant at high efficiency and to maintain the economy day in and day out, it is necessary to keep accurate records of output, input and all essential operating conditions. Pressures, temperatures, vacuums, flow of steam and water, weights of coal and ash, draft, CO_2 averages and electrical output, current and voltage, as they relate to the different equipment of the plant, should be known. The old method of tapping a boiler with a hammer to determine the water level has been long replaced by a water glass. The steam-pressure gage and other indicating gages and meters are now regarded as necessities and may be found in plants of all capacities. When enough of these instruments are installed to give the principal operating data, economical results may be expected. The degree of economy depends on how frequently the instruments are read and with what degree of intelligence the readings are interpreted.

While indicating meters are essential and have their place in every plant, they have their limitations. Readings made at intervals and averaged over a period of twenty-four hours are not the equivalent of a continuous record showing conditions at all times. In fact, an average of several individual readings may mean little or nothing to the engineer endeavoring to analyze plant performance. With accurate recording meters he cannot well go astray. Complete records for the entire period are before him and are comparable for any particular instant or over any period of the twenty-four hours. It is comparatively recently that the true importance of the recording meter is being realized. Electrical instruments of the recording or integrating type are not new, but continuous records of draft, flue temperature, CO_2 and boiler output are exceptions rather than the rule.

In office-building plants this is particularly true, the very place where a multiplicity of service should demand more instruments than other types of plant. With elevator service, electrical current for lighting and power, heating and ventilation, vacuum cleaning, refrigeration, hot and cold water and perhaps other services, it is difficult indeed to compute or estimate accurately the cost of any particular service. The management of any building can give you the total cost of the plant, and this may be reduced to a charge per square foot of floor space, but when it comes to dividing these totals between the service, only rough approximations are available. A lack of meters, both indicating and recording, is largely responsible for more reasons than one. It is important to know the proportionate cost of each service, and of more importance still to know that the plant as a whole, and particularly the boiler room which is the primary source of all the services, is operating at high efficiency and that this efficiency is being maintained. In both cases meters are the solution, and particularly recording meters.

In this direction a notable advance has been made in the Conway building plant, described on other pages of this issue. There are plenty of indicating meters of all descriptions and, of special importance, a number of recording instruments. Electrical meters separate the elevator, power and lighting loads, a dumping meter measures the returns from the heating system, efficiency meters record the drop in draft through the boilers, and others give continuous records of boiler pressure, feedwater temperature and quantity, density of smoke, etc. While meters are still lacking to permit a complete and accurate separation of all the services, there is a great improvement in this respect over the average plant.

There is of course a limit to the expenditure in meters, and this must be determined by the capacity, requirements and the possibility of saving in each particular case. No plant, however, should lack instruments to indicate or record the more important data, and in the interests of economy it is to be hoped that other plants will follow in the footsteps of the new building.

The Engineer and the Fireman

Coöperation invariably leads to higher efficiency and greater economy. In the power plant, however, where mutual help is so important, there are striking examples of failure to render such assistance as might result advantageously to all concerned. How often does the engineer, for instance, realize that he can be of material benefit to the fireman and greatly enhance not only the latter's value to the management, but also his own? If the engineer and fireman would get together and help each other, the resulting economies would be surprising.

The duty of the fireman is to generate steam as economically as possible, and that of the engineer is to use this steam as economically as possible. The more economical the engineer is in the use of steam, the simpler it is for the fireman to generate that steam. He must furnish steam of requisite quality, however, or no amount of care on the part of the engineer can cause the engines to develop satisfactory power. The engineer can only do his best with the steam that is supplied and for this steam the fireman is responsible, so he is indirectly responsible for the showing made by the engineer.

The engineer knows, or should know, the kind and quality of steam he needs. The fireman, on the other hand, though he should be able to generate any quality of steam within the capability of his boiler, cannot know as well as the engineer what the latter desires. The engineer may not know as much about generating steam as the fireman, and, as obviously, the fireman does not know as much about using his steam economically or the requirements for the economic consumption of steam. Mutual help alone can lead to combined efficiency and economy.

The fireman is not usually qualified to instruct the engineer in the use of steam, and the engineer may not at once be qualified to show the fireman anything, but he should learn, with the fireman's assistance, how to operate

economically and efficiently the boiler serving his engine. He should learn all the fireman can teach him, and then both can add to their mutual store of knowledge.

The way for the engineer to learn to operate the boiler efficiently is to devote his spare time actually to firing and experimenting with fuel depths for various loads, damper openings, the height of the bridge-wall best suited for normal operation, and to become familiar with all the various duties required of the fireman. This requires considerable diplomacy.

The engineer should have some good reason to advance for making any experiment, and if he has not made himself a nuisance to the boiler-room force, he will find the average fireman ready and anxious to try anything that promises success. The fireman, at the same time, should realize that the interests of the engineer and his own are similar and give the value of his hard-earned knowledge.

If the engineer and the fireman get together, the results are bound to be beneficial. Savings as great as twenty-five per cent. in the consumption of coal have been secured in plants where an engineer devoted an hour or so each day to working with his fireman. This man confined his experimenting to one boiler and never disturbed the rest of the firemen, but still interested them to such an extent that they followed closely the experiments of active co-operation and patterned their own methods of firing and caring for their boilers after that of the experimenters.

When producers and consumers coöperate, benefits invariably accrue to both. More such coöperation in the power plant would mean much to all, from the management down to the ash handler.

Wasting Energy in Defending One's Mistakes

Few engineers have a record free from mistakes, but many can say truthfully that they never made the same error twice. It is only human for man to err in judgment or in action. When the young engineer makes his first blunder, though it be one not resulting in loss of life or personal injury or even immediate serious damage to the plant, he probably feels that his reputation will be ruined when it is discovered, and he is blue indeed.

In such a situation it is worse than useless to try to conceal the mistake, if it is beyond remedying, and to attempt to bluff the matter out in the face of the evidence is even more foolish. The effect of a chief's error upon those lower in rank is, unfortunately, disturbing to their entire confidence in him, but they will respect his frank acknowledgment of the mistake; and if he is right most of the time, he can afford to admit his defections in the sight of his subordinates.

The real rub comes in dealing with one's superior. Perhaps the boss finds in an estimate a misplaced decimal point which, if undiscovered, might have cost the plant owner thousands of dollars, or maybe the engineer has to report that a certain piece of auxiliary equipment has been injured or reduced in capacity through a mistake in repair methods attempted by the local staff under the chief's direction. The sense of discredit from such experiences is hard to bear, but the fault must be acknowledged in order to be fair with the staff in the station or to prove oneself absolutely on the level; and all honor to the engineer with the courage and manliness to face the situation at its worst!

After acknowledging his mistake, the engineer is still more to be commended if he does not attempt to offer extenuating excuses. If the "boss" wants to know how a mistake was made, let him be told, but generally a few words of explanation, including self-blame where it is merited, should suffice. The right kind of a superior wants results rather than explanations and appreciates a short, regretful admission of fault because it betokens determination not to repeat the error.

To delay finding out why something goes wrong is often a worse mistake than the original one. Thus, if the engineer discovers an error in a submitted estimate, it is not sufficient to report it, but corrected figures should be offered at once. The lesson to be learned is the importance of carefully checking one's figures the first time. It is far better, for example, to nip an error in planimetering an indicator diagram before the total power output goes into the record than to have it show up afterward.

In any event, whatever the slip, nothing helps one to recover lost ground and live down the effects more than to shoulder the blame and give assurance not to again be found culpable.

Still No Hall of Records Data

Power continues to receive inquiries relative to the "Hall of Records Test"—perhaps the most complete investigation of power-plant operation ever attempted, and the results of which were to decide whether New York City can operate plants in its public buildings as cheaply as it can purchase electricity. It is felt that *Power* readers are entitled to know the present status of the case.

The test was started on Dec. 15, 1912, and ended Dec. 15, 1913, just one year later. After a reasonable time had elapsed (sufficient for analyzing the results had the client been a private company or individual), information as to the outcome was sought, but the response to every inquiry was that the advisory board, consisting of Professors R. C. Carpenter and C. E. Lucke, and R. P. Bolton, E. F. Tweedy, E. P. Goodrich and G. F. Sever, were still deliberating.

On Jan. 7, 1915, a request was made to F. A. Cleveland, Director of the Bureau of Municipal Research, under whose supervision the test was made, asking permission to study the test data. Dr. Cleveland was favorable to the proposition, but stated that he would first have to obtain the necessary permission from the advisory board. One week later he advised that the matter had been taken up with the board, and that with one exception the members had refused to grant the request.

From information gleaned from other sources, however, it can safely be said that, had the results been less favorable to the contentions of the city, they would have been made public long ago.

The question has been asked: "Are the members of the advisory board of engineers on the Hall of Records test being paid by time or by contract?"

Investigation by the Government has disclosed that fifty-six per cent. of the present water-power development in the United States is controlled by six corporations.

Correspondence

The War and Electric Power in Hungary

With the exception of eastern Prussia, Hungary has perhaps seen more actual fighting than any other section belonging to the Central Powers. It is therefore of interest to learn from a lecture by D. Jakobowits before the Hungarian Electrotechnical Association, that the power-transmission systems have suffered only slightly in those parts where fighting occurred. Electrical-power generation and transmission in Hungary, however, have felt the influence of the war in many different ways.

Many of the power plants have Diesel motors, either as main units or for reserve capacity. This was very convenient in times of peace, when oil could be easily obtained from the Galician fields, but during the Russian occupation of the Galician oil fields many of those plants using Diesel motors exclusively were seriously handicapped. The plants using coal found that the demands of the military authorities frequently interfered with their interests, so that here and there the power distribution for street lighting had to be curtailed.

As in Germany, a larger demand for energy for electric-lighting purposes has been reported from the agricultural districts while the demand for power for small motors in industrial districts has declined. On the other hand, large industrial users have been fairly active buyers. The financial situation of the electrical industry has been satisfactory, as the payments for electrical energy were excluded from the general moratorium.

New York City. LUDWIG W. SCHMIDT.

Central-Station Rate Making

I have read with interest the several discussions of my article on "Central-Station Rate Making," which appeared in the Aug. 24 issue. Replying first to the criticisms by Henry D. Jackson (Nov. 2 issue), it may be pointed out that a sizable book might be written covering the pros and cons of the subject, and that the article aims only at a brief explanation of the elementary considerations. However, the definite criticisms will be met in order as follows:

1. The proper basis for the assessment of demand charges is a question admitting of endless argument. I would refer Mr. Jackson to the statement in the article wherein it is affirmed that a distribution of this charge on a basis of the consumer's sharing of the station peak is "probably the more equitable one," but may or may not be practical, depending on the available meter equipment. Furthermore, a strict adherence to this principle may defeat its own purpose in that a consumer whose load did not infringe on the station peak would obtain the services of the station equipment at a cost covering only the operating expenses.

2. In assuming that the sum of the group maxima (4,608 kw.) represents the peak load on the station, Mr. Jackson fails to consider the interweave between the several groups. The peak of the actual load curve on which the example was based amounted to but 2,800 kw.

3. The attention of Mr. Jackson is called to the fact that the figure 0.7, which he has taken to be the general "diversity factor" on residences, is the "interweave" factor for the residences as regards their group only. The actual general diversity factor is the ratio between the 1,660-kw. group maximum and the 4,000-kw. connected load of the group, or 0.415. Taking the reciprocal of 0.415 to bring it into the form of Mr. Jackson's figure, we have 2.41, which seems fair. The particular figure of 4.13 given by the Commonwealth Edison Co. is only one isolated value. Furthermore, lighting connections are usually much overrated in contract writing and consequently on the company's books. To illustrate: The Philadelphia Electric Co. rates its small-residence connections as being the equivalent of twenty-five 50-watt lamps, whereas it is highly improbable that the average small residence contains more than 20 lamp sockets and not all of these sockets are fitted with 50-watt lamps. Mr. Jackson's confusion as to diversity factors seems to apply to the remaining groups also.

4. I agree with Mr. Jackson's contention that equipment costs and energy costs depend on the character of the load. However, to have involved the example with all the detailed considerations upon which these costs depend would have defeated the aim of the article.

The discussion presented by Mr. Tarr, while distinctly constructive and instructive, is admittedly from the viewpoint of a power salesman. Mr. Tarr is getting right back to the "value of service" theory, the backbone of the argument on which have been built so many extortionate retail rates. I grant that it certainly would cost the lighting consumers more, were they to operate a group plant for their own service only; but this admission in no wise carries with it an agreement that such a cost is the measure of the portion of the total costs of a utility company (engaged in a general lighting and power business) which is incurred by the said consumers. The whole discussion reverts to the question of "cost of service" versus "value of service" as the basis for rate making.

The writer has taken Mr. Tarr's rates as formulated for the wholesale users, has assumed that, were these power consumers to each own and operate small individual plants to supply their own needs, they could generate at an "energy" cost of 1.5c. per kw.-hr. (only 15 per cent. above the cost at the large central station), and has capitalized the difference between this 1.5c. energy cost and Mr. Tarr's rates at 12 per cent., this to cover only interest, depreciation, taxes and insurance—administration, superintendence, etc., being neglected. On this basis there would be justified a capital investment by the wholesale users of $146,000, enough to install only 1,460 kw. capacity at $100 per kw.—a capacity quite inadequate to meet their demands. There should indeed be but little difficulty in persuading them to accept the service of the central station at the proposed

rates, considerable of their share of the fixed expenses being borne by the retail users.

I appreciate thoroughly Mr. Tarr's argument that wholesale business must first be got before there can be the opportunity for sharing of expense. But is Mr. Tarr willing to admit a general inability of efficiently organized and operated central stations to deliver energy at the same or less real total cost than the average relatively small isolated plant? If, however, the station is so able, and if the general public, which gives a monopolistic grant to the utility, is accorded fair treatment, then all well and good. But if the public is made to pay its own share of expense and profit plus a considerable portion of the expenses incurred by the large user, not because of economic necessity, but only in order that the utility may put excessive profit in its own pocket, then the situation becomes unfair and uneconomic. Perhaps conditions would have been reversed had central stations been primarily developed by groups of larger power users for their own service and the general enfranchised lighting business been opened up later as an outlet for equipment otherwise standing idle at night.

The criticisms of Mr. Jackson and Mr. Tarr serve admirably to bring out the two sides of the question of central station rate making. PAUL J. KIEFER.

Philadelphia, Penn.

Repairs to Cast-Iron Tank

A cast-iron hot-water tank 2x7 ft., for special service, after only about 18 months' use, developed a crack 6 in. long in the shell and extending across the manhole flange. The crack was grooved on the inside, and lamp-wick saturated with Smooth-On was tamped in, but next day it leaked as badly as ever when under a water pressure of about 130 lb. Welders were called in, but would not guarantee a good job. As the installation cost was about $1,000, something had to be done.

Two 1-in. round-iron hoops with draw-clamps were put on and drawn up tightly around the tank and one around the manhole flange, after the crack had been filled with Smooth-On cement. On the inside a piece of sheet packing was placed, and a copper patch 4x8x1/8 in. was screwed down over all, with 1/4-in. brass capscrews 3/4 in. long, spaced 1 in. apart, the shell being 1 1/4 in. thick. The tank has since been in use for six months and is holding just as well as when new. W. T. OSBORN.

Newark, N. J.

Testing Pure Mineral Oils

An item on page 854 of the Dec. 21 issue reads as follows: "Pure mineral oils do not contain fatty acids, so that even a trace of acid is pretty conclusive evidence of a compounded oil." Pure mineral oils, it is true, do not contain fatty acids, but the trace of an acid does not necessarily indicate that the oil is compounded.

Sulphuric acid is used in the refining of mineral oils to precipitate the foreign matter and mechanically bring down the free carbon. After being washed, caustic soda is then used to neutralize any remaining sulphuric acid. If the latter process is not carried to completion, the refined oil will show a trace of acid which is not fatty.

A simple test for an oil compounded with a fatty oil is to add a small piece of potassium hydrate to a little of the oil and heat in a test tube or some similar container. A jelly-like substance will be the result if the mineral oil is compounded with a fatty oil; a pure mineral oil will not be affected.

To test for sulphuric acid, add warm water to the oil, shake vigorously for ten or fifteen minutes and allow the mixture to stand and separate. Draw off the water from the bottom of the container and add one or two drops of methyl orange solution (1 gr. to 1 liter of water). A pink or red solution denotes the presence of an acid.

New York City. L. F. LYNE, JR.

Poor Engineering Ruins Company

In the Middle West an ice plant was built to produce 60 tons per day. In operation it produced but 37 tons, and three engineers, running it in succession one season each, failed to raise the daily production above 37 tons. At the end of the third year the company failed, and the plant passed into the hands of its competitor. Under the new management and under the operation of another engineer the plant still yielded only 37 tons per day until the operator proposed that the plant be examined, even dismantled if necessary, to discover the defect. His advice was followed, and the examination had not gone far before the cause of the trouble was found.

There were two brine tanks, and the pipes which carried the ammonia gas from them connected into a 6-in. main near the forecooler. This 6-in. pipe, the engineer was told, was "connected to a header into which several 2-in. pipes were connected." These 2-in. pipes ran the length of the forecooler, entering another header at the top of the forecooler, and from the top header the 6-in. ammonia suction pipe was led off. The 2-in. pipes had been put into the forecooler to cool the distilled water. For some reason these pipes had been surrounded by a wooden box-like structure, making it impossible to see the inside of the forecooler without taking it apart. When this was done, it was discovered that there were but three 2-in. pipes to take gas from the 6-in. pipe and pass it into the continuation of the same large pipe or suction. The engineer drilled and tapped the forecooler headers for nine more 2-in. pipes, after which the capacity of the plant was 60 tons per day.

The engineer who erected the plant had failed actually to compute or consider the carrying capacity of these pipes, and each of the three operating engineers had failed to discover his error. The result of this mistake and the inability of three men to unearth it was the failure of the enterprise.

The first feature of this incident that impresses the man who looks on is the risk the construction engineer was willing to take with the business interests of his clients. It seems hardly possible that he did not know that 3 times 2 are not 6 when the 2 and the 6 represent the diameters of circles, used to compute their areas. The incident should impress this man with the importance of taking measurements and of making careful computations.

The second thing about this incident is the failure of each of three engineers to measure up to the opportunity before him and win a reputation for himself. Only the fourth man appears to have had knowledge of that class of plant intimate and accurate enough to justify him in

attempting to discover what was wrong. His predecessors had been convinced that something was wrong, no doubt. But what it was and where to look for it constituted too much of a problem for them to undertake.

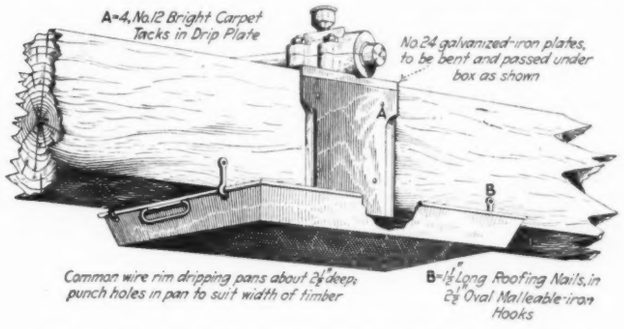
The big hint in this incident is to the employer. If the original owners of this plant had had sufficient business foresight to employ an engineer who was really competent, they might be in business and making money today. Economy at the point where competence is required is generally false economy, and sometimes is so far from real economy that it spells ruin.

New York City. H. G. WHITE.

Drip Pans Under Bearings

To prevent oil and grease dripping from the bearing supports of the elevators and conveyors at our coal docks and yards we have put drip pans under all bearings, thereby reducing also the fire hazard by preventing the grease dropping on the coal.

There is always a large amount of coal dust and dirt accumulating in the grease on the side of the bearing


A=4, No.12 Bright Carpet Tacks in Drip Plate
No.24 galvanized-iron plates, to be bent and passed under box as shown
A
B
Common wire rim dripping pans about 2½" deep; punch holes in pan to suit width of timber
B=1½" Long Roofing Nails, in 2½" Oval Malleable-iron Hooks

OIL-DRIP PAN AND SIDE PLATE UNDER BEARING

timbers, but it is easy now to clean or wipe this off and also to clean out the drip pan below by unhooking it. The drip pan should be a couple of inches wider than the bearing timber and have holes punched in it to suit the width of the timbers, to receive the hooks, which are standard commercial articles and can be bought in almost any general store.

We also whitewash all the timber supports to reduce the fire hazard to the minimum.

St. Paul, Minn. NATHANIEL HANSON.

Overcoming Static Effects

In a printing shop where many large motor-driven presses are used much trouble was caused by the sheets of paper becoming charged with static electricity as they left the cylinders, which would not allow them to square up right on the delivery board for cutting. This was overcome by installing an electric neutralizer consisting of a step-up transformer and neutralizing combs, the latter placed across the presses just over the carriers where the newly printed sheets are taken off the cylinders.

As direct-current service is employed exclusively, a 1¾-hp. motor-generator set is used. The motor runs on 240 volts direct current and drives an alternating-current generator which gives 70 volts on the alternating-current side to the closed-core transformer, where it is raised to 15,000 volts. The transformer is single-phase, with a frequency of 60 cycles, and together with the motor-generator set, is located in the cellar directly under the pressroom and as nearly central as possible, so that the induction leakage will be small.

The comb is an iron support for small porcelain sections with galvanized centers, to collect induction from the high-tension cable. The induction passes through holes ¼ in. diameter (and chamfered at the outlets) in the porcelain insulators, in which there are galvanized points for guiding its discharge. W. T. OSBORN.

Newark, N. J.

Some Early Uniflow Engines

For the past few years I have been interested in the various accounts and performances of the uniflow engine. These have brought to mind some experience that I had with that style of engine nearly twenty years ago. At that time I had charge of the designing and experimental department of the Sawyer & Massey Co., Ltd., Hamilton, Canada, builders of traction engines and threshers. Their chief trade was, and is now, with the Canadian West. In the early part of March, 1896, W. F. Cleveland, one of the two brothers that invented this uniflow engine, arrived at the office of the Sawyer & Massey Co. He came from near Brandon, Manitoba, was born and brought up in New Brunswick, and I think

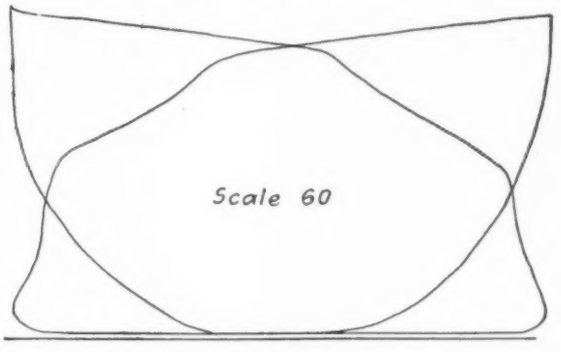


DIAGRAM NO. 1

Duration of test	1 hour
Cutoff, about 0.6 of the stroke	
Average speed, r.p.m.	225
Average pressure (boiler), lb. gage	110
Average brake load, b.hp.	32.62
Average m.e.p., lb. per sq. in.	73.7
Average i.hp.	39.5
Average back pressure, lb. gage	2
Steam consumption, lb. per b.hp. per hour	40.8
Steam consumption, lb. per i.hp. per hour	33.7

belonged to that branch of the New England Clevelands from which the late President Cleveland descended.

Mr. Cleveland's mission was to introduce a new steam engine on the uniflow principle. H. P. Cobourn, the vice-president and general manager, after consulting with the general superintendent of construction, M. Garvin, also George Kirkland, who was the manager of the North West branches and happened to be at the home office, decided upon a trial—chiefly through the advice of Mr. Kirkland.

Mr. Cleveland had the cylinder part of his engine built at Brandon, Manitoba, and it had been in use and on trial there. It was decided to wire Brandon and have the cylinder brought to Hamilton by express. It came in about a week, and we had to change our engine bed to suit it. It was then erected on one of our regular traction engines.

Only the cylinder with steam chest and valves was supplied. The bore was 7¾ in., stroke 10 in. The cylinder was about twice the ordinary length, the exhaust ports were around the cylinder at the center of its length, and a long hollow piston acted as the main exhaust valve. The steam chest was long, with a valve at each end of the cylinder. I think they were piston valves, but I am not sure about this. The induction, or steam, valves acted also as relief valves to relieve the excessive compression. The steam port at each end was very short, and the clearance space was small.

This engine was one of our regular traction engines, controlled by a regular link motion. All traction engines are noncondensing and throttle-governed. The governor was a 2-in. Waters on a 2-in. steam pipe with a 2½-in. exhaust pipe reduced to 1¼-in. at the nozzle and leading to the smoke-stack. The piston, or slide, valves when acting as relief valves connected with passages that carried the relief exhaust to the main exhaust belt.

The engine was tested with a prony friction brake, and indicator cards were taken at the same time. The engine stood outside of the building containing the prony

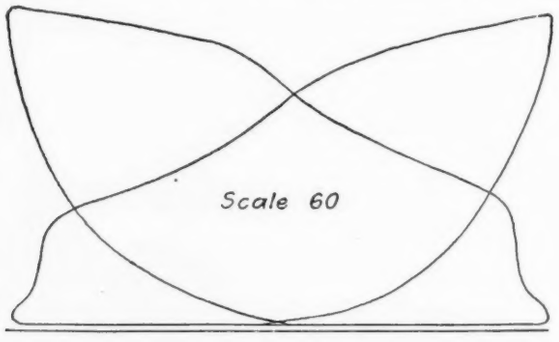


DIAGRAM NO. 2

Duration of test	1 hour
Cutoff, about 0.6 of the stroke	
Average speed, r.p.m.	223
Average steam pressure, lb. gage	110
Average brake load, i.hp., about	25
Average m.e.p., lb. per sq.in.	57.65
Average i.hp.	30.5
Average back pressure, lb. gage	2

friction brake, and the belt was about 100 ft. long and 6 in. wide. I think the cylinder was lagged with wood and sheet iron. The steam pipe from the dome on the boiler was short, but not covered with any nonconducting substance; steam would not be very dry. The diagrams herewith were taken during this test. On diagram 1 the weight of water used per horsepower-hour was marked. On the test when diagram No. 2 was taken, there appears no account of water used, so that it is impossible to give the consumption of steam. The pulley on the engine and that on the friction brake were 40 in. diameter. The belt from the engine to the friction brake had to be strained very tight, causing considerable loss of power from friction, the brake horsepower being about 7 less than the indicated horsepower. Both diagrams show considerable compression, but very little back pressure until compression begins.

About 1897 Mr. Cleveland induced the Canadian Intercolonial Ry. at Monctown, N. B., to put his uniflow cylinder on locomotive No. 59, but I do not know how this turned out.

The Cleveland brothers took out their first United States patent, No. 551,262, Dec. 10, 1895; their second, No. 553,747, Jan. 28, 1896. L. J. Todd, the English inventor of the uniflow principle, took out his patent in 1886. Johann Stumpf took out a number of United States patents. Patent No. 982,395, Jan. 24, 1911, was for a piston-controlled exhaust. Patent No. 994,484, June 6, 1911, appears to be his first patent with the uniflow principle and would seem to conflict with the Todd and Cleveland patents. ROBERT CHRISTIE.

Hamilton, Canada.

Static Effects on Lamp Filaments

In the Oct. 19 issue F. S. Wilson referred to lamp filaments being destroyed by static electricity.

In a power plant where I was employed we had a centrifugal pump belted to a motor. As this was in a rather dark place in the basement, a lamp was hung directly over the belt. Different methods were tried for static discharge, but lamp filaments continued to be destroyed. We finally placed a wire guard around the lamp and grounded the guard, and our troubles disappeared.

Albuquerque, N. M. H. V. FRANK.

Can Soot Formation Be Prevented?

W. F. Schaphorst's letter, "Can Soot Formation Be Prevented?" published in the Dec. 14, 1915 issue, page 834, interested me. I have never heard of any way to prevent soot, and I believe that no matter what method of firing is used, soot will form.

There can be no doubt that soot influences efficiency. In our plant we are operating two 300-hp. water-tube boilers, and each is equipped with a mechanical soot cleaner. Before we put these cleaners in, we used to blow with the hose and lance once every twenty-four hours. Now we blow once every eight hours, and we notice the increased efficiency. The temperature of the stack gases has been reduced 70 deg. at normal load since using the blowers. While I do not know how much the coal consumption has been decreased, I do know we use less than before installing the blowers.

Detroit, Mich. A. W. VAN EPPS.

Priming Caused Engine Trouble

I once had charge of a new 1,200-hp. compound Corliss engine that caused considerable worry by a peculiar groaning sound in its high-pressure exhaust valves when working on small overloads. We tried refitting the valves and the operating connections, and also forced in considerable oil of various grades, by means of handpumps, but all to no avail.

After considerable experimenting, we found that the steam was very wet, at overloads, from priming caused by the use of too much soda ash in the boilers. Cutting down the soda ash reduced the priming and our valve trouble disappeared at the same time. Of course, we then reasoned that the wet steam had caused imperfect lubrication of the valves while we had been expecting to find trouble in the valves themselves.

Detroit, Mich. B. W. DENNIS.

Inquiries of General Interest

Insulating Material for Refrigerating Plants—What properties should be possessed by insulating material used in refrigeration plants? H. C. R.

The insulating material should have a large proportion of dead air space per unit of volume, should be compact, should absorb moisture very slowly and should disintegrate only slowly when either wet or dry.

Salt Dissolved by Boiler Water—What quantity of common salt can be held in solution by the water of a boiler that is under 100 lb. gage pressure? A. S. L.

Water at 212 deg. F. will dissolve about 3¾ lb. of common salt per gallon, and for higher temperatures there is dissolved about 0.03 of one ounce more per gallon for each additional degree Fahrenheit. The temperature of the water of a boiler at 100 lb. gage pressure would be 338 deg. F., and at that temperature the amount of salt held in solution could be about

$$3.33 + \left[(338 - 212) \times \frac{0.03}{16}\right] = 3.56 \text{ lb. per gal. of water}$$

Furnace Economy Indicated by Smoke—What proportion of combustible is carried off in smoke emitted from boiler furnaces? A. R. J.

The amount of carbon and other combustibles carried away by smoke does not usually exceed 1 per cent. of the combustible elements of the coal. The presence of smoke, however, often is an indication of improper firing that may result in much larger waste of the fuel. As smoke is produced when incandescent particles of carbon are cooled before coming in contact with sufficient oxygen to unite with them, any such condition of furnace management will result in smoke.

Electrical Resistance of Mercury Column—What is the electrical resistance in ohms of a round column of mercury 72.3 in. high and 0.04 in. in diameter at 32 deg. F.? G. B.

The cross-sectional area of the mercurial column would be $0.04 \times 0.04 \times 0.7854 = 0.0012566$ sq.in., and as 1 sq.in. = 1,273,240 circ.mils, the cross-section would be $1{,}273{,}240 \times 0.0012566 = 1{,}600$ circ.mils (approx.). The resistance of a column of mercury having a cross-sectional area of 1 circ.-mil and 1 ft. long at 32 deg. F. is 565.88 ohms, and as the resistance varies inversely as the cross-section and directly as the length, the resistance of the column in question would be

$$\frac{565.88 \times 72.3}{1{,}600 \times 12} = 2.13 \text{ ohms.}$$

Expression for Steam Consumption from Diagram—In the expression

$$\frac{13{,}750}{\text{m.e.p.}} [(C + E)\ We - (H + E)\ Wh]$$

for computing the steam consumption of an engine from an indicator diagram, quoted on page 695, of the Nov. 16 issue, what does "13,750" stand for? F. B. Q.

The quantity 13,750 when divided by the m.e.p. gives the cubic feet of piston displacement per hour for each horsepower developed by an engine, whatever its size or speed. An explanation of the derivation of the different members of the complete expression is given in "The Steam Engine Indicator," by F. R. Low, Chapter XV, entitled "Steam Consumption from the Diagram."

Rate of Condensation in Pipe-Coil Radiator—How much condensation per hour would be formed in a pipe-coil radiator containing 280 lin.ft. of 1-in. pipe, when supplied with steam at 120 lb. gage pressure and surrounded by an atmospheric temperature of 85 deg. F.? J. W. D.

One lineal foot of 1-in. steam pipe has an external surface of 0.344 sq.ft., and 280 lin.ft. would have an external surface of $280 \times 0.344 = 96.3$ sq.ft. The temperature of steam at 120 lb. gage, or 135 lb. absolute, is about 350 deg. F., and the difference of temperature inside and outside of the pipe would be $350 - 85 = 265$ deg. F. The rate of transfer of heat would depend on the character of circulation of the steam, the nature of the surface of the pipe—that is, whether smooth, rough, painted, dry or oiled—and on the activity of ventilation of the atmosphere surrounding the pipes, but for ordinary conditions would amount to about 2.5 B.t.u. per hr. per sq.ft. of surface per degree of difference of temperature. Therefore radiation of heat would take place at the rate of about $96.3 \times 265 \times 2.5 = 63{,}798$ B.t.u. per hr.

In condensing the steam would lose only its latent heat. Referring to the steam tables, it may be seen that the latent heat of steam at 135 lb. per sq.in. absolute is 869.9 B.t.u. per lb. (weight), and therefore there would be $63{,}798 \div 869.9 = 73.3$ lb. of steam condensed per hour.

Fire Risk from Use of Fuel Oil—How is the fire risk of a power plant increased when oil is used as fuel for boiler furnaces? R. G.

There is little danger from the oil itself. When oil, such as commonly used, is heated much above 140 deg. F., gases are formed that are highly explosive upon coming in contact with air. Such gases may be formed from overheating the oil, either from the sun or proximity of the oil to the furnace; or if air is forced through the oil, it becomes saturated with inflammable gases. Such gases may be formed from churning the oil, as by passing it continuously from a relief valve to an oil-pump suction. But with ordinary precautions these dangers are comparatively slight when fuel oil is used for stationary boilers.

Safe Pressure for Longitudinal Joint of Steam Drum—With a factor of safety of 6, what would be the allowable pressure for a 40-in. diameter steam drum, as determined by the strength of the longitudinal seam made with lap-joint, double-riveted, where the thickness of the cylindrical shell is ⅝ in., tensile strength of shell plate 55,000 lb., diameter of rivets after driving $1\frac{1}{8}$ in., shearing strength of rivets 42,000 lb. per sq.in. of cross-section, pitch of rivets 3½ in.? J. A. D.

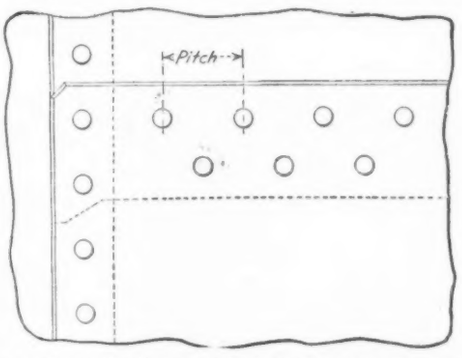


DIAGRAM OF DOUBLE-RIVETED LAP JOINT, SHOWING UNIT OF PITCH

For a length of the joint equal to a unit of pitch: The strength of plate between rivet holes would be

$$(3.5 - 1\tfrac{1}{8}) \times \tfrac{5}{8} \times 55{,}000 = 52{,}852 \text{ lb.} \quad (1)$$

the shearing strength of two rivets in single shear would be

$$2 \times 42{,}000 \times (1\tfrac{1}{8} \times 1\tfrac{1}{8} \times 0.7854) = 57{,}984 \text{ lb.} \quad (2)$$

and, allowing the crushing strength of the plate to be 95,000 lb. per sq.in., the crushing strength of plate in front of two rivets would be

$$2 \times (1\tfrac{1}{8} \times \tfrac{5}{8}) \times 95{,}000 = 66{,}797 \text{ lb.} \quad (3)$$

As the strength of the joint would depend on (1), namely, 52,852 lb. per unit pitch, or 3.5 in. length of joint, then with a factor of safety of 6, the allowable stress per inch length of joint would be $\frac{52{,}852}{3.5 \times 6} = 2{,}516.76$ lb.

When a cylindrical shell resists internal pressure, the hoop stress brought upon 1 in. length of a longitudinal joint is equal to ½ the diameter of the shell in inches multiplied by the pressure per square inch. Therefore, with an allowable stress of 2,516.76 lb. per in. length of joint and 40 in. diameter of shell, the allowable pressure would be $2{,}516.76 \div \frac{1}{2}$ of 40, or 125.8 lb. per sq.in.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Siller-Christians Boiler

The conversion of water into steam comprises two distinct processes—the raising of the temperature of the water to the boiling point and its evaporation at that temperature. For the greatest efficiency the gases must transfer the greatest possible amount of heat to the water; that is, they must leave at the lowest possible temperature, which involves the necessity that they shall, on leaving, encounter surfaces cooled by the coolest, or incoming, water. The transfer of heat depends upon the difference between the temperature of the gas and that of the water, and the counterflow process is most favorable to this condition.

The Siller-Christians boiler, made by Siller & Jamart, of Barmen, Germany, is built in recognition of these principles. As diagrammatically shown in Fig. 1, it consists of a preheater through the coils of which the water is forced positively by the feed pump. The gases pass across the coils in the direction counter to that in which the water progresses and leave after contact with the portions of the coils containing the coolest water. The movement of the water is forced and rapid, so that it must pass on to progressively hotter and hotter regions, leaving the surface which has just furnished heat to it free to be used by other cooler water.

The evaporation of the water is mainly effected in units, one of which is shown at the left in Fig. 1. The flow of the water over the surfaces here is not positive, as in the heating portion, but is due to circulation induced by density difference, which circulation is clockwise, as the loop stands to the reader in the illustration. The steam generated is discharged at *a*, water to replace it being taken in at *b*, and provision for the use of a special cleaner is made at *c*.

As the adaption of the two divisions of the process to varying conditions of firing and steam demand would

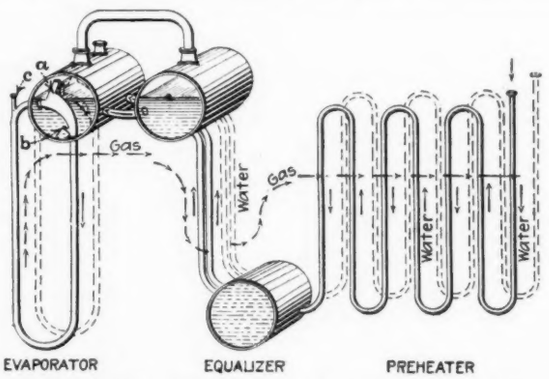


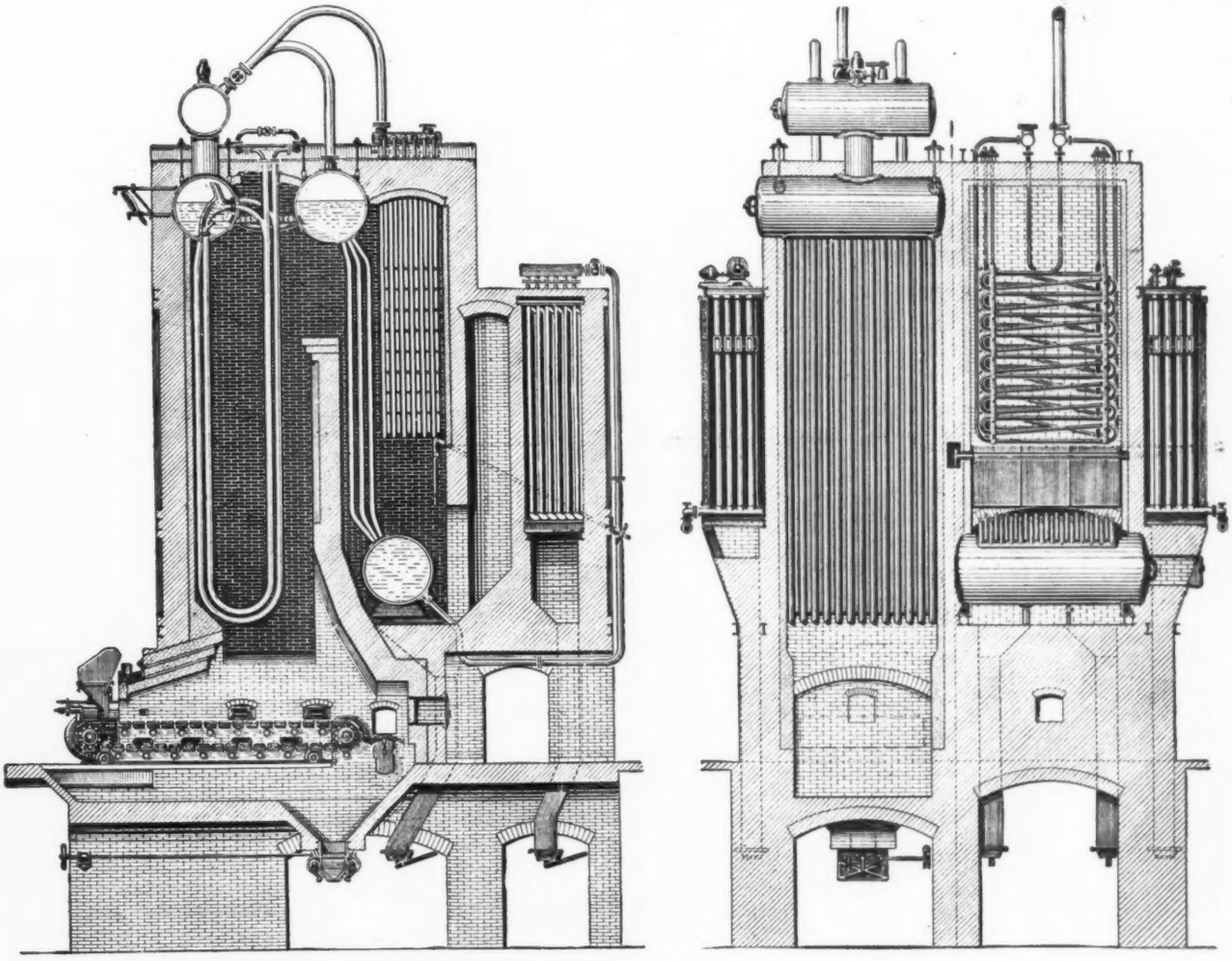
FIG. 1. SHOWING COUNTERFLOW OF GAS AND WATER

be impracticable, an equalizer is used between the heating and evaporating portions. The heat absorbed by this may be used to increase the temperature, to vaporize, or both, provision being made to liberate any steam which may be generated and conduct it to the steam space of the right-hand steam drum.

Fig. 3 shows the setting of one of these boilers. It will be seen that the counterflow principle is still further invoked by the use of an economizer ahead of the

FIG. 2. THE LARGEST BOILER IN EXISTENCE, 29,600 SQ.FT. OF HEATING SURFACE

first circulating heating portion of the boiler, making it really a three-stage unit. Fig. 2 is a reproduction of a photograph taken during the erection of what is claimed to be the largest unit in Europe, at the Reisholz Station of the Rheinisch-Westfälisches Elektrizitätswerk A. G. near Düsseldorf. Here the economizer is at the left, behind the boiler. The heating surface of the boiler proper is given as 2,750 sq.m. (29,600 sq.ft.), and it evaporates from 56,000 to 60,000 kg. of water per hour from 30 deg. C. into steam of 15 atmospheres and 350 deg. C., equivalent in round numbers to 123,200 to 132,000 lb. from feed water of 86 deg. F. into steam of 220 lb.



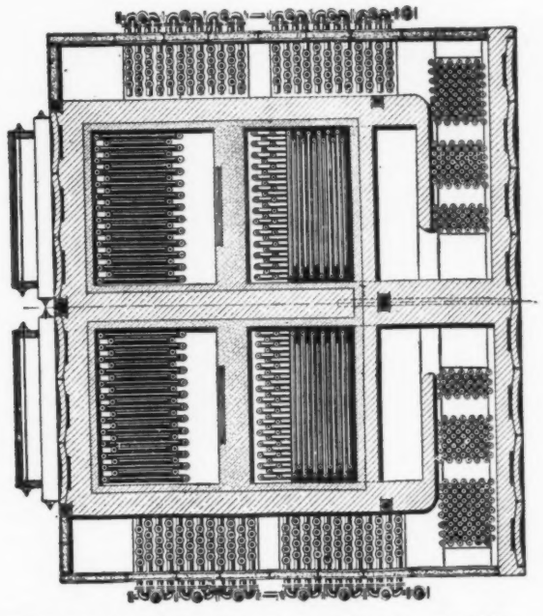


FIG. 3. SETTING OF THE SILLER-CHRISTIANS BOILER

and about 600 deg. F. The highest rate is less than 4.5 lb. evaporated per square foot of heating surface per hour.

An efficiency of 90 per cent. is claimed. This is evidently the combined efficiency of economizer, boiler and superheater, but is almost unbelievably good even for that. Unfortunately, no figures are given from actual tests.

Peat as a Fuel for Boilers—An Amsterdam newspaper prints an extract from a scientific journal stating that "turf-poeder" (peat in a powdery form) has long been used in Sweden as a fuel for stationary boilers, and that recent experiments in that country with railroad locomotive boilers show that 1¼ tons of peat powder equal 1 ton of the best English coal for steaming purposes. According to estimates, the peat moors of the Netherlands contain fully 100,000 million kilos (about 100,000,000 long tons) of ready-to-burn peat, which is equivalent to about 75,000,000 tons of best English coal, according to the Swedish experiment, and that this fuel is immediately available. The newspaper adds that the price of "burger-turf" (a short, hard peat burning a long time) is 11 to 13 florins ($4.42 to $5.23) per ton, while the best English coal costs 16 florins ($6.43).—Consul Frank W. Mahin, in "Commerce Reporter."

Low-Grade Fuels in Producers

Technical Paper No. 123, recently issued by the Bureau of Mines, contains some notes on the use of low-grade fuel in Europe as gathered last year by R. H. Fernald. Unfortunately the notes are incomplete, as Professor Fernald's trip was cut short by the outbreak of the war. Some of his observations are substantially as follows:

One of the most serious difficulties encountered in the use of high-ash fuels is excessive clinkering. The interruptions from such clinkering and the failure of the plant to develop rated capacity for continued periods make the satisfactory use of such fuels questionable. The demand for a gas producer to handle all grades of fuel, especially those grades usually sent to the dump, has recently brought to the European market the revolving eccentric-grate producer. Among the advantages claimed for this type, as compared with the fixed-grate type, may be mentioned automatic ash removal instead of ash removal by hand, thus insuring lower labor cost, more uniform and more complete combustion, operation for months without interruption, ability to handle much more fuel per square foot of fuel area, less space for 1,000 cu.ft. of gas produced, freedom from dust and the usual excessively hot and dirty conditions during removal of ash, the production of a gas of closely uniform quality and a reduction in the cost of upkeep.

In this type of producer the degree of eccentricity may be varied to suit the grade of fuel handled. For fuels that give no trouble from clinkering or from which the ash is fine, the eccentricity may be reduced to zero, but for fuels that give excessive clinkering troubles or from which the ash is coarse, the eccentric grate is found of value, and it tends to grind the ash in a manner to prevent the clogging of the system. The speed at which the grate revolves is determined by the ash content of the fuel and the demand upon the producer. The usual speed, however, is from ⅛ to 1¼ revolutions per hour. At this low speed little power is required to drive the grate, and in practice it is customary to install motors of from one to two horsepower for this purpose.

JACKETED VS. JACKETLESS PRODUCERS

Experience with European fuels has shown that even with the eccentric revolving grate and the usual producer-shell construction, clinkering troubles are not entirely eliminated when a low-grade fuel with low ash-fusing temperature is employed. A further improvement feature for overcoming clinkering and the tendency of the ash to fuse with the producer lining is water-jacketing the part of the producer shell surrounding the hot zone. The extent of this jacketing varies from none with coals that give no trouble from clinkering to a maximum for those that give such clinkering and fusing difficulties. Also, revolving-grate producers are made of either the dry- or the wet-bottom type. For extremely fine fuels, such as fine slack and coke breeze, requiring relatively high air pressure for successful gasification, the dry-bottom ashpit is regarded by some as more desirable on account of the excessive depth of water required by the wet-bottom type.

The revolving-grate producers are reported to gasify two to three times as much fuel per square foot of fuel-bed area per hour as can be gasified in corresponding updraft pressure producers with fixed grates. In the operation of the plants gas leakage is small, as poking of the bed is reduced to a minimum.

The claims advanced are that not more than one-fourth as much steam is required in the jacketed producer as in the jacketless type with a fixed grate. The figures given for comparison are one pound of steam per pound of fuel for the fixed-grate jacketless producer and 0.25 lb. for the revolving eccentric-grate jacketed producer. Results in the United States, however, indicate that one pound of steam per pound of coal is rather high for plants of good size and that 0.7 lb. is nearer the figure unless the plant be indifferently operated. However, the cost of these revolving-grate jacketed producers is necessarily high.

UTILIZATION OF REFUSE MATERIAL

Within the past five or six years marked progress has been made in Europe in the utilization of various kinds of refuse material not ordinarily given much consideration. The manufacturers of gas producers report the successful use of a large variety of fuels, including wood shavings, wood blocks, sawdust, excelsior, coffee husks, rice husks, cocoanut shells, straw and spent tanbark. The figures on fuel consumption reported by the manufacturers are about as follows: With reasonably dry wood (say mixed oak, ash and elm), the consumption has been as low as 2 lb. per b.hp.-hr.; with sawdust the consumption averages 3½ lb. per b.hp.-hr.; and with spent tanbark containing 50 per cent. moisture it is about 4½ lb. Plants for such fuels are made in sizes ranging from 25 to 500 hp., and the producers may be of either the downdraft or the updraft types. With the latter a tar extractor is necessary.

In connection with byproduct-gas installations serious consideration has been given in Europe to the utilization of low-grade materials, and several installations have been made with the avowed purpose of using the refuse at the collieries. It seems, however, that after a brief period of operation the possibilities of immediate financial returns overshadow interests in true economy and maximum utilization of fuel resources, with the result that in the majority of cases the poorer grades of coal have been reconsigned to the dump and commercially marketable high-grade fuel has been used in these byproduct plants even when erected at the mines. These plants are in many cases of large size, ranging from 2,000 to 30,000 hp.

By many, the blast-furnace type of gas producer is regarded as presenting problems in upkeep that make the cost of the plant prohibitive. As one man put it, "After a few hours' run the plant is out of commission for several days for relining." Others with whom this subject was discussed see nothing in the blast-furnace type. They feel that the varied character of the ash makes the fusing indefinite and unreliable; one day it fuses and the next day it does not, no practical success having been attained from such plants.

Hazards in Handling Gasoline

In connection with investigations regarding safety and efficiency in the use of petroleum and its products, the Bureau of Mines has made numerous tests of gasoline and kerosene, and in Technical Paper 127, by G. A. Burrell, states the hazards that may result from handling these liquids and the precautions to be observed.

Gasoline vapor mingles with air in the same manner that water vapor does, the amount carried depending upon the temperature of the air and the readiness with which the vapor can be obtained. If one takes the cover off a full pail of tightly inclosed gasoline and applies a match to the surface the gasoline will flare up and burn as long as the gasoline lasts. On the other hand, if one puts a few drops of gasoline in a small, tightly inclosed pail, waits a few minutes and then produces a flame or an electric spark, a violent explosion will likely result. In the first case the vapor burns as fast as it comes from the gasoline and mixes with the oxygen of the air; whereas in the second case the oil vaporizes in the pail and mixes uniformly with the air to form an explosive mixture and, upon ignition, explodes. One gallon of gasoline when entirely vaporized produces about 32 cu.ft. of vapor. If a lighted match could be applied to pure gasoline vapor in the absence of air, no fire or explosion would result.

At ordinary temperatures air will hold from 5 to 28 per cent. of gasoline vapor, depending upon the grade of gasoline. The author found that in 100 parts by volume of air and gasoline an explosion would not take place if there were less than 1.4 parts of gasoline or more than 6 parts. In other words, the explosive range is between 1.4 and 6 per cent. of vapor. Flashes of flame will appear in mixtures containing considerably smaller and larger proportions of vapor and considerable pressure will be developed, but propagation through the mixture will not take place. One gallon of gasoline can, under ideal conditions, render 2,100 cu.ft. of air explosive.

Where benzine, gasoline, naphtha and other inflammable liquids are employed, care should be taken to see that the smallest practicable quantities are used and that these are handled in an approved manner. No open light or flame of any kind, nor any machine or belts capable of producing a spark should be allowed in a room where the gasoline is used, all shafting or machines with belts that are liable to cause a static spark should be well grounded, and only incandescent electric lamps should be used, these being provided with guards to prevent being smashed. All switches, fuses, etc., should be outside the room. Danger signs should be posted on all doors opening into the room, warning against the carrying of open lights inside.

When large quantities of inflammable liquids are used, the main supply should be stored in a metal tank buried under ground at a safe distance from the buildings. The working supply should be pumped into the building as needed and so arranged that when the pump is stopped all liquid in the pipes will flow back into the supply tank, and the gasoline barrels should be stored in the open air with the bungholes down. Rooms in which explosives or dangerous gases or vapors are used or generated, should be provided with an improved system of ventilation; as gasoline vapor is heavier than air, a suction fan will insure proper ventilation.

There are two principal methods of extinguishing burning liquids: (1) To form a blanket of gas or solid material over

the liquid and cut off the air supply; (2) to dilute the burning liquid with a noninflammable extinguishing agent that will mix with it.

Water may be used for extinguishing liquids such as denatured alcohol, wood alcohol and acetone, that are miscible with it. If such a liquid as gasoline, which does not mix with water, catches fire, the application of water produces little or no effect except to spread the burning liquid. However, the application of a large quantity of water to a small quantity of burning oil, by its cooling effect, may aid in extinguishing the fire. Among materials used to form a blanket of gas or solid material over the burning liquid may be mentioned sawdust, sand, carbon tetrachloride and the so-called foam or frothy mixtures.

The efficacy of sawdust is due to its floating for a time on the liquid and excluding the oxygen of the air. Sawdust itself is not easily ignitible and, when it does ignite, burns without flame. The character of the sawdust and its moisture content is of little or no importance. It may be well handled for extinguishing small fires when just started, by means of long-handled wooden shovels. Sand probably serves about as well as sawdust for extinguishing fires on the ground, but is heavier and more awkward to handle. When thrown on a burning tank, it sinks, whereas sawdust floats. Carbon tetrachloride, the basis of various chemical fire extinguishers, when thrown on a fire, forms a heavy non inflammable vapor over the liquid and mixes readily with oils, waxes, etc. The vapor is about five times as heavy as air, and its success depends largely upon the skill of the user. If liquid in a tank is on fire, the height of the liquid is important. When the liquid is low, the sides of the tank form a wall which retains the vapor, but when the tank is nearly full of highly volatile liquid like gasoline, only the most skilled operator can extinguish the fire.

Use of Superheated Steam in Marine Practice*

By Henry B. Oatley

SYNOPSIS—Superheaters in marine service eight and twelve years without needing repairing. Metal in contact with highly superheated steam should contain no copper or brass. Superheaters should be of steel. Piston valves are recommended for high superheat and cylinders, liners, steam chests, packing and piston rings should be of close-grained cast iron. Longer cutoff needed with high superheat. Hints on starting and on lubrication when using superheated steam.

It appears that a well-designed superheater, even one developing high degrees of superheat, has a life as long as that of the boiler tubes. Many instances have come to the attention of the writer where the life of some of these superheaters has been more than 8 years, and in some cases 12 years, without repairs. It would seem not at all unreasonable to expect superheater equipment to have a life practically as long as the boiler itself. If this is obtainable many of the objections to superheating should be removed, and in many cases, even if the life of the equipment were less than 8 years, where fuel economies of 10 per cent. and upward are obtained there would still be considerable on the credit side of the account.

The following are details, aside from the superheater, which require investigation if superheated steam is to be used: Steam pipes, valves and fittings; steam-chest valves; engine cylinders, liners, etc.; piston rings; rod packings and cylinder ratios. Steam pipes, stop valves and fittings should contain no copper or brass. Many governmental regulations prohibit cast iron and malleable iron. The rules of the United States Steamboat Inspection Service require steel where pressures of more than 300 lb. and a temperature of more than 425 deg. F. are used. This requirement is adhered to in the best practice both here and abroad. The main stop valve should have a cast-steel body, and the valve spindle should be steel.

Steam-chest valves on the high-pressure cylinders should be of the piston type with rings, whenever the superheat is sufficient to eliminate all condensation in the first cylinder. Balance slide valves on the high-pressure chests have been satisfactorily operated in some instances, but as a rule if the temperature of the steam is 500 deg. or more, piston valves are recommended. For the intermediate chests of triple and quadruple engines and for the low-pressure of compounds, piston valves are desirable. But well-balanced slide valves, if properly provided with grooves for lubrication, have been successfully used. Slide valves for the low-pressure cylinders of triple and quadruple engines appear to be safe.

Engine cylinders and liners must be of first-class close-grained cast iron, as hard as can be worked. Cast iron does not lose strength, but on the contrary gains slightly when exposed to temperatures up to 800 deg. F. It is probable that under exceptionally high temperatures cast iron may grow, but within the range of temperatures to which steam chests and cylinders are subjected, with superheated steam, no appreciable change will be found. Piston and valve rings should be of cast iron. There is a growing tendency toward the use of soft cast iron instead of white metal for piston-rod packing, and it is claimed that all the requirements are met by this iron.

The published dimensions of English and German superheated steamships show that a lower cylinder ratio is used than is common here. It is generally accomplished by increasing the diameter of the high-pressure cylinder, the intermediate and the low-pressure diameters on a triple engine remain as with saturated steam. In quadruple engines the the high- and first intermediate-pressure cylinders are increased in diameter, while no change is made in the second intermediate- and low-pressure cylinders. In converting engines from the use of saturated to superheated steam an increase in the high-pressure cylinder diameter is not always advisable, and many times not possible. In such cases, if the same indicated horsepower is to be obtained, it is necessary to increase the cutoff in the high-pressure cylinder, giving an increased volume of steam at cutoff and ending by decreasing the cylinder ratio. To explain the necessity for these modifications, it will only be needed to point out that the expansion curve of superheated steam falls a little more rapidly than for saturated steam; to make up for this the volume of steam at cutoff with, say, 200 deg. superheat would be about 10 per cent. greater than the volume with saturated steam, to get equal power. This does not mean, of course, that the same weight of steam is used per stroke, after superheating. It merely means that a 10 per cent. greater volume of steam, which weighs about 30 per cent. less per unit of volume than saturated steam, is used. These figures indicate that there is still a considerable margin of steam economy, although a greater volume of steam per stroke is taken.

The two points to consider are starting and lubrication. In starting, particularly with new engines or if new liners or rings have been applied, nearly all superheater manufacturers will recommend that saturated steam be used for a short time. After the engine is well heated the mixing valve (valve in a pipe leading saturated steam to the main steam pipe and superheated steam to the auxiliary steam pipe) may be closed and the temperature of the steam in the high-pressure chest gradually raised; some hours should elapse before the full degree of superheat is used. In this way the wearing surface will have an opportunity of taking on a smooth finish.

With low degrees of superheat it is not always necessary to use oil internally. This may be explained by the fact that the superheat is not sufficient to carry the steam through the high-pressure cylinder without condensation. When condensation occurs oil lubrication may not be necessary, and this is particularly true when low pressures are carried. Low superheat really does little more than eliminate part of the initial condensation. With moderate degrees of superheat, opinions differ as to the necessity for the use of oil. Cases are on record where superheat of more than 100 deg. has been successfully taken care of without internal oil lubrication.

*Excerpts from a paper read before the 23rd meeting of the Society of Naval Architects and Marine Engineers.

It seems probable, however, that in such cases heavy swabbing of rods was resorted to. When high degrees of superheat are considered, lubricating oils should certainly be applied internally. The quantity of oil needed to satisfactorily take care of 150 deg. or more of superheat is probably imagined as being greater than the amount actually required. The average of a large number of boats using superheat shows that favorable results were obtained with about $\frac{3}{10}$ gal. of oil per 24,000 hp.-hr. One case has been reported of a 2,800-hp. ship that used but 20.5 gal. of oil on a 42-day voyage. This is about 0.5 gal. per day.

The keynote of the lubrication question with highly superheated steam is that a regular supply, rather than a large quantity, of oil is required.

Heating by Forced Circulation of Hot Water in Textile Mills*

By Albert Greene Duncan

SYNOPSIS—This paper treats of the method of using hot water to heat, through direct heating surface, the various rooms of a large textile mill, the water being heated by live or exhaust steam in closed heaters in a central plant, and the hot water being distributed by forced circulation.

Since the days of the old coal stove, three methods of heating textile mills have been in use: Direct live or exhaust steam at low pressure; fan or indirect hot air heated by coils arranged in a central battery; and direct hot water in the various rooms, heating the water with either live or exhaust steam in closed heaters. The gravity, or it might be called the house heating system, was impracticable, so that forced circulation of the hot water was selected for heating the widely separated units of the Harmony textile mills at Cohoes, N. Y., after the relative advantages and disadvantages of all three of the foregoing methods were considered.

This system was adopted for the following main reasons: (a) The mills are primarily driven by water power, and the auxiliary steam plant is situated at a central point, the distribution of power being by electricity. (b) The central-plant arrangement necessitated the carrying of heat a distance of 1,650 and 1,370 ft., in opposite directions, respectively. (c) As certain of the mills were below the level of the power plant, a gravity system of return, either of hot water or steam, was impracticable.

The mills consist of seven buildings, varying in size from 40x100 to 76x1,073 ft., containing 825,434 sq.ft. of floor surface and 10,354,000 cu.ft. content. The buildings are of various types, erected during a period of many years. One, of three stories, was put up in 1837, and the largest mill, of five stories with basement, was built in 1876.

The general direction of the mills is north and south, and the east side of the longer mill is on the top of a bluff 80 ft. above the river and exposed to extremely high winds. Temperatures of 20 deg. F. below zero are not uncommon, and the question of exposures was a special problem. Further than this, the plant, naturally divided itself by its configuration into two manufacturing groups approximately equal in area; and consideration was given to the possibility, in times of curtailment, of shutting down either of these groups and running the other at full capacity.

From experience gained from this installation, the author has no hesitancy in stating that excessive use of coal in any mill-heating problem is largely a direct consequence of overheating. With a distributing steam coil always at a high temperature, the local regulation of heat is generally left to the individual overseer, whose method of lowering the temperature is usually that of opening windows rather than closing valves. It was determined that the regulation of the heat should be placed under the charge of the engineer in the power house, and long-distance reading thermometers were installed so that the temperature in different portions of the plant could be read by him there. Thus the two primary factors of heat control—the temperature of the water and the speed of its circulation—could be accurately regulated in accordance with outside temperature. It was felt that the ability to control the temperature of water from a range of 100 to 240 deg. F. gave a flexibility to the system impossible of attainment in any other way, while a forced circulation of hot water can be readily regulated to meet all manufacturing and weather conditions and will maintain its efficiency at any degree of temperature.

*Presented at the annual meeting (December, 1915) of the American Society of Mechanical Engineers.

The questions of relative cost of installation and the cost of operating the hot-water system compared with a modern direct steam-radiation system showed the following interesting facts:

The amount of radiating surface required for each, if exhaust steam at 2 or 3 lb. per sq.in. pressure were used, would be practically the same, since the temperature of the heating surface would be practically the same. In extremely cold weather, with hot water the temperature of the surface could, however, be raised to as high as 240 deg., which would correspond to steam at 10 lb. pressure. This temperature could be obtained in the steam system only by raising the back-pressure or injecting live steam. However, a point in favor of a decreased amount of actual radiating coils in a hot-water system is that the mains can be figured as part of the heating surface, the circulation being so rapid that the temperature is adequately maintained to the end of the run with none of the choking and heat losses due to condensation where steam mains are used in the same manner.

In determining the amount of radiating surface required in various departments the number of heat units required were determined as in any other method of heating and the well-known factors were used. Table 1 is submitted as a basis for future determinations, bearing in mind that many modifying conditions apply which must be decided by the judgment of the engineer in each individual case. The difference in temperature figured was 70 deg. and the heat as that required to maintain 70 deg. in zero weather with water at 212 deg. For temperatures below zero, it was considered that the ability to heat water to 240 deg. and the heat given off by mill machinery in operation were ample margins of safety.

TABLE 1. HEAT LOSS IN B.T.U. PER HR. PER SQ.FT. OF EXPOSED OUTSIDE SURFACE OF BUILDING FOR 1 DEG. F. DIFFERENCE IN TEMPERATURE BETWEEN INSIDE AND OUTSIDE AIR

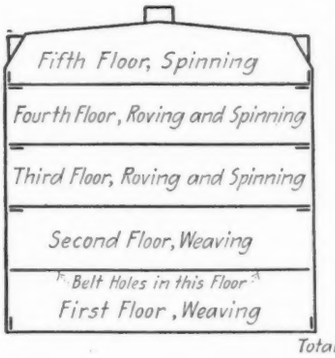
Medium	Heat Loss, B.t.u.
8-in. solid brick wall	0.40
12-in. solid brick wall	0.31
16-in. solid brick wall	0.26
20-in. solid brick wall	0.23
24-in. solid brick wall	0.21
28-in. solid brick wall	0.19
Single window	1.00
Double window	0.50
Slate on tight wood roof	0.30
Standard mill roof 2½ in. plant t. and g.	0.18

The engineer will find plenty of opportunity for the exercise of his judgment in determining the percentage loss of heat to allow for leakage, window exposure, roof exposure and other factors depending in each case upon the location of the building, besides the loss of heat by the opening of doors into cooler hallways and elevator shafts to allow of transportation of stock in process, loss by the removal of warm air from picker rooms by the picker fans, etc.

In comparing the cost of a forced-circulation hot-water system with that of a good exhaust-steam system, it may be said that with the exception of the additional cost of the pumping plant required by the former, the cost of installation of either is about the same. The cost of maintenance of the hot-water system is believed to be much the lower by virtue of gradual rather than sudden changes of temperature of radiating surface and absence of water-hammer.

Fig. 1, which refers to one of the largest of the mill units, will make clear the proportioning of heating coils. The departments in this five-story mill are shown in transverse section, together with the location of the heating coils on the side walls or ceilings. In this building there are about 1,500 belt openings between the first and second floors. The table referring to each floor shows in the first column the heat

required without taking into consideration leakage and wind exposure, in the second column the heat required with these factors allowed for, in the third the heat actually provided for in proportioning the heating surface and in the last column the percentage each floor contained of the total amount of heating surface in the building. It will be seen that the figures in the third column are not in the same ratio as those in the second column, although the totals are the same. The character of manufacturing operation in each department was a determining factor, and experience with the system later showed that more coils were placed upon the top floor and



	1	2	3	4
	B.t.u. Required without Leakage & Wind Exposure	B.t.u. Required with Leakage & Wind Exposure	B.t.u. actually Provided For	Percentage Each Floor is to Total Radiation
Fifth Floor, Spinning	1,810,000	2,672,100	1,778,000	24.0
Fourth Floor, Roving and Spinning	1,003,000	1,308,900	928,700	12.5
Third Floor, Roving and Spinning	877,400	1,158,000	1,348,100	18.1
Second Floor, Weaving	877,400	1,158,000	1,151,400	15.5
First Floor, Weaving	865,000	1,128,900	2,219,700	29.9
Total	5,432,800	7,425,900	7,425,900	100 Per Cent.

FIG. 1. SECTION OF MILL UNIT AND PROPORTIONING OF HEATING COILS

fewer upon the lower floor than were actually needed, this being due to belt openings mentioned and to the natural effect of heat leaking up through elevator shafts and other passages to the top floor, which also contained the spinning machinery, the kind of cotton machinery producing the most heat.

The heart of a forced-circulation hot-water system is the pumping plant. The essentials of each unit are a closed heater of the ordinary feed-water type, together with a pump for each section of the mills. Each pump is connected to its own heater and is so arranged that in case of breakdown the third pump or heater can be used interchangeably with either of the two sections of the system. A type of heater with a short coil is preferable, to be run with the steam inside the coils surrounded by the water in the shell; this is an essential feature of the system, as the heater coil must be so proportioned as to clear itself readily of the water of condensation, which, especially at times of starting up, is large in volume.

The heaters are of extra-large capacity and adapted to use exhaust steam in any but the most extreme weather, when live steam is used. The three heaters are connected with a boiler feed-water heater of the same size. By valves, a greater or less amount of the exhaust steam can be used in the circulating-water heaters or the feed-water heater as required, and the circulating water maintained at any desired temperature.

The drips are collected in an open heater to which the makeup water of the boiler plant is added and pumped back through the closed feed-water heater to the boilers. No rule can be laid down as to the form of pump required, but each case must be decided by the character and service of the power station of which the system is a part. In the present instance a large amount of exhaust steam from auxiliaries was not available at all times, the main steam turbine being run condensing under high vacuum. For this reason steam-driven pumps were installed, and it was found in practice that, except in extreme weather, they furnished sufficient steam to properly heat the circulating water, and as the returns from the heaters were immediately delivered to the boilers, very little loss occurred in the transfer of heat to the circulating water.

In cases where a power station is used as a primary source of power, where large amounts of steam are used for service pumps or other purposes, an electrically driven or other form of power-driven pump might prove most desirable. But, unless the power plant operates on a 24-hr. basis, a method of pumping by steam for a portion of each day should be installed, as it is the universal experience of textile mills that the larger part of the heat required during the 24-hr. day must be supplied when the mill is not running. With the exception of a few departments, such as weaving, in any but the most extreme weather the heat engendered by the machinery is sufficient to keep the rooms at working temperature after 8 or 9 a.m. Details of this gain in heat from the machinery will be taken up later. Although the cost would vary in different plants, it may be stated that in the example under consideration the cost of the pumping plant was 29 per cent. of the total for the system.

After three years of operation, careful records can be given showing the result of the system in actual service. The steam pipe supplying the turbine pumps, from which also the live steam was taken for the heaters in case of need, was furnished with a steam meter, and as a check, all other lines in the power plant were also metered. The total result was checked by a venturi meter on the feed-water side, and over a period of years the sum of these metered results checked within approximately 5 per cent., an amount which could be easily accounted for by boiler blowoffs, leakage, emptying of boilers and other minor losses. Another meter was placed in the branch line feeding the circulating pumps alone, so that by subtracting the amount of steam required to drive the pumps, the steam going direct to the heaters could be accurately determined. A third meter in connection with the heating system was installed in the exhaust pipe as a check upon both the amount and the direction of flow of steam, as to whether or not the heaters were receiving exhaust steam from power-plant auxiliaries, or whether exhaust from the circulating pumps was being put into the feed-water heater supplying the boilers. Furthermore, two other flow meters measured all the water circulating through each of the two parts of the system, and the two main pipe lines were equipped with recording thermometers, giving the temperature of flow and return in each.

During the first year (1912-13) considerable attention was given to the compilation of data for making a thorough study of the conditions, with a view to obtaining the best possible results. During a part of that year very extensive readings were taken of temperature, humidity, amount of radiation in service, number of windows open, if any, etc. At the same time recording thermometers giving the temperature of flow and returns in the power plant were checked up frequently. A part of the records for the heating season of 1912-13 and the totals and averages for the heating seasons of 1913-14 and 1914-15, respectively, are given in Table 2. During the first half of the 1912-13 heating season, neither the mill conditions nor the method of operating the heating system were on a regular working basis. Subsequent to Feb. 1, 1913, no changes of material consequence that would affect the heating requirements or the method of operating the system have been

TABLE 2. OPERATION OF HARMONY MILLS' HEATING SYSTEM

Week Ending	Average Outside Temp., Deg. F.	Total Steam to Pumps and Heaters, 1,000 Lb.	Average Boiler Hp. Equivalent 24 Hr.	Total Heat in Steam, Million B.t.u.	No. 1 Group of Mills: Per Cent. Time System in Service	No. 1 Group of Mills: Total Pumpage, Million Lb. Water	No. 1 Group of Mills: Temperature Water Flow, Deg. F.	No. 1 Group of Mills: Temperature Drop in Return, Deg. F.	No. 1 Group of Mills: Heat Supplied to Mill, Million B.t.u.	No. 1 Group of Mills: Mill Temperature, Deg. F.	No. 1 Group of Mills: Per Cent. Total Radiation in Service During Working Hours	No. 3 Mill: Per Cent. Time System in Service	No. 3 Mill: Total Pumpage, Million Lb. Water	No. 3 Mill: Temperature Water Flow, Deg. F.	No. 3 Mill: Temperature Drop in Return, Deg. F.	No. 3 Mill: Heat Supplied to Mill, Million B.t.u.	No. 3 Mill: Mill Temperature, Deg. F.	No. 3 Mill: Per Cent. Total Radiation in Service During Working Hours	Total Heat Supplied to Both Mills, Million B.t.u.
Jan. 4, 1913....	39	1,269	223	1,255	100	85.3	150	7.4	614	75	68	92	90.5	149	8.0	720	77	54	1,334
11, ...	31	1,427	251	1,410	98	77.3	153	7.7	586	73	61	90	86.3	151	9.5	834	75	64	1,420
18, ...	36	1,014	177	994	99	68.9	137	5.6	420	75	67	69	62.4	143	8.8	557	77	60	977
25, ...	36	1,015	178	1,000	100	73.2	135	5.4	410	75	61	92	83.3	136	7.3	623	77	68	1,033
Feb. 1, ...	33	1,108	194	1,091	100	71.6	140	6.0	429	74	61	93	84.8	138	7.8	677	77	70	1,106
8, ...	21	1,756	306	1,719	100	85.8	156	8.4	726	75	72	99	96.1	158	10.1	969	78	62	1,695
15, ...	17	1,877	327	1,838	99	83.6	161	10.4	848	75	80	99	91.2	160	10.6	981	78	62	1,829
22, ...	27	1,405	246	1,381	96	74.9	152	8.2	606	75	75	86	77.7	147	9.1	724	77	59	1,330
Mar. 1, ...	25	1,437	253	1,423	100	78.4	156	8.0	647	76	74	94	87.9	144	8.8	788	78	56	1,435
25 weeks, 1912-13.	37	26,038	184	25,778	78	1,499.9	148	...	11,569	..	..	64	1,481.5	145	...	13,969	..	..	25,538
26 weeks, 1913-14.	31	28,355	192	28,041	72	1,160.3	149	...	....	73	..	66	1,244.5	136	...	....	74	..	....
25 weeks, 1914-15.	35	28,025	198	27,747	73	1,270.7	145	...	....	74	..	64	1,278.9	128	...	....	74	..	....

made in the mill. The figures for 1912-13 show a reasonably close agreement between the total heat supplied to the system as shown by the steam passing through the meters and that calculated from the pumpage and temperature drop between flow and return. In arriving at the total heat units in the water, it is necessary to multiply the pumpage by the temperature drop on each individual day, for in compiling the average temperature drop for a week, each day has been given equal weight, although all days may not have represented equal quantities of water.

During the past two years considerable trouble has been experienced in maintaining accuracy of the recording thermometers, and the temperature drop is not dependable for calculating the total B.t.u., and as the temperature drop seldom exceeds 10 deg. even 1 deg. error in the thermometers would amount to 10 per cent. of the heat so calculated.

The figures giving the average boiler horsepower for 24 hr. are significant, and the author believes that no such result has ever before been accomplished in a textile mill of this size. Previous experience in other mills, of about half the size of this one, heated by a combination system of direct steam and indirect hot air, showed that approximately twice the horsepower was required in proportion to the size of the respective mills.

Figs. 2, 3 and 4 indicate the relations between outside temperature, temperature of circulating water and total steam used. Fig. 2 shows the temperature of water required for different outside temperatures. The upper line represents the original instructions by the engineer of the system, and the lower line represents the modified instructions followed by the power-plant engineer since Feb. 1, 1913. The dotted line shows the average temperature of water that has been

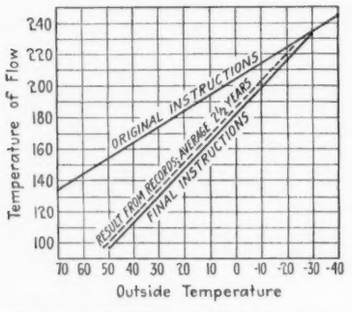


FIG. 2. TEMPERATURE OF WATER FOR VARIOUS OUTSIDE TEMPERATURES

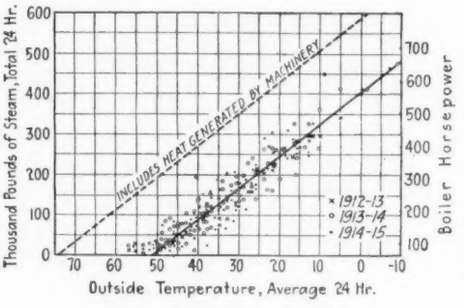


FIG. 3. TOTAL STEAM CONSUMPTION PER DAY

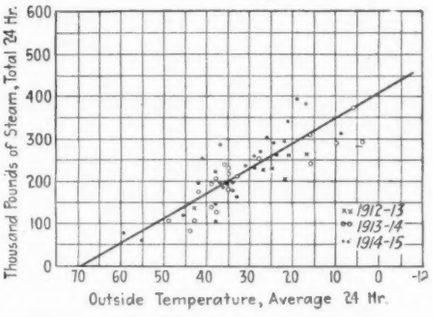


FIG. 4. HEAT SUPPLIED DURING SUNDAYS AND HOLIDAYS MILL INOPERATIVE

maintained during the past 2½ yr. After the operation of the system had become thoroughly standardized, a marked saving in temperature of water and consequently in coal was effected. This result was accomplished after careful study of the amount of heat given off by manufacturing and machinery, attention to double windows over 80 per cent. of the mill, elimination of drafts through stairways and elevator shafts, and other conditions which prevented the system working at its best efficiency, and proves the chief claim made at the beginning, that centralized control of heating in textile mills is the most efficient method.

Fig. 3 shows a plot of the total steam consumption per day with different outside temperatures during all full working days, when the system was in operation, during the past 2½ yr. Mondays and the days following holidays are excluded, as some extra heat is required to bring the mill temperature back to normal on those days. It is noted from the average curve drawn through these points that 500 boiler horsepower is required in zero weather. No heat whatever is required when the outside temperature is above 50 to 55 deg., yet 75 deg. is maintained throughout the mills. It must be remembered that about 7,000 hp. is used to drive the machinery and all this power is dissipated in heat from the spinning frames and other machinery, and its total heat equivalent is about 180,000,000 B.t.u. per 10-hr. day, or substantially 180,000 lb. of steam. If this heat equivalent is added to that supplied to the heating system, we find the upper dotted line extended to the base line would indicate no heat required with an outside temperature of 74 deg. F., which is substantially the average mill temperature maintained.

Fig. 4 gives a plot of heat supplied to the mills Sundays and holidays during the same period, but it was not the intention to maintain full working temperature, and a drop of 5 to 10 deg. usually took place, which was made up on the day following. Therefore the heat on these days was less and that supplied on Mondays and the days following holidays was greater. An average line through the plotted points intersects the base line at an outside temperature of about 70 deg. and shows conclusively that more heat was supplied to the mills on Sundays and holidays than on full working days, even though the same temperature was not maintained.

Two other points are brought out by these diagrams—the amount of heat required at zero weather is evidently the same on Sundays as on working days, and also there is a much closer agreement between the temperature of circulating water as actually carried and that contemplated by the contractor at zero weather than at higher temperatures. These facts point toward the conclusion that substantially the same heat is required from the heating system when the outside temperature is zero or below, whether the mill is running or not. The reason for this is that when the mill is running, the heat given off by the machines is offset by an extra circulation of air through the buildings owing to the frequent opening of doors, the operation of elevators, etc., thereby causing a much greater leakage or circulation through the mill than takes place on Sundays and holidays when the mill is not in operation. There is also a decided chimney action in heated buildings 60 to 75 ft. in height, sucking cold air into the lower floors and discharging it from the upper ones, and this increases very noticeably as the outside temperature approaches zero.

During the first year the question of wind velocities was looked into, but there was no indication that it was a factor of sufficient importance to warrant including it in addition to the outside temperature in the operating instructions.

The operation of this system has demonstrated two facts—that the proper heating of textile mills is based on the one hand on a thorough understanding of the engineering problems involved, and on the other hand on a careful watching of losses of heat, which can be most readily accomplished by having the plant under centralized control.

Losses in heat arise from many causes. Our experience shows that the benefit of double windows offsets their cost many times, not only on the side of the mill exposed to prevailing winds, but on all sides; in this case 80 per cent. of the mill windows are doub. . Openings from the heated rooms to entryways and elevator shafts are a constant cause of loss, especially at night, and during the first years, constant vigilance was necessary to impress upon night watchmen the importance of keeping all such openings closed, otherwise all the heat becomes centered in the upper story, where it is lost by the opening of windows, to keep the room at a working temperature. By proper regulation, except in extreme weather, heating can be confined in the daytime to the lower floors of the mill, to the weaving and carding departments, and to portions of the mill where very little machinery is in operation.

Certain other general subjects naturally fall within the limits of this discussion. The relative merits of heating circulating water by live steam or exhaust is a matter to be decided entirely for the individual plant, as already indicated, and is based upon the conditions of the power-plant operation and the available supply of exhaust steam.

Offices or other rooms may require more heat or heat at different times of the day than is required in the mills and may not share in receiving heat from manufacturing and machinery, so must be separately provided for. These, however, represent usually but a small percentage of the total heat required, so that the general problem is not greatly affected.

In the mill in question, the office building is a detached structure, and during the first year of operation a large amount of heat was wasted by having it connected to the main mill system, as heat was required in offices on mild days when none should have been used in the mills. This difficulty was overcome by installing a siphon system of heating and circulating the water in this building by a special form of

ejector or steam siphon which could be operated or closed off entirely independent of the mill system. The steam so added is condensed and added to the water of the system. This, together with the air, is taken care of through an expansion tank and relief valve, from which it is returned to the heaters in the power plant. The disagreeable noise encountered by this method was overcome by the simple expedient of two lengths of railroad rubber steam hose.

The method of distribution used was the standard one, running the supply mains to the top floor of the respective mills and then, after distribution through the coils on this floor, returning the water through return drops to the return mains placed in the bottom story; in other words, the distribution was in a vertical direction. Experience is a valuable teacher, and in the installation described a method of running circulation coils would have been preferable to the one used, although not affecting the efficiency of the heating system. A method of circulating the water through each floor or department by itself, leading out of and returning to vertical risers and return mains is preferred in a cotton mill using different processes on each floor, as it enables the heat to be put on and taken off each department by the operation of the fewest possible valves. This can be so systematized by a study of records that, except for sudden changes of temperature, the heating can be done on a regular schedule independent of the control of the working force in any department. This may seem to modify the point first made as to centralizing control and applies more in textile plants than in any other mills, because of the varying degree of import of heat due to manufacturing processes on the various floors, and especially the upper floors where it is the general practice to install spinning machinery.

The author is indebted to Ervin G. Bailey and Frederick W. Parks, who furnished the tables and calculations.

Behavior of Boilers in Service*

By J. C. McCabe†

SYNOPSIS—Some of the causes and conditions which tend to induce failures or minor troubles in steam boilers. Tube and drum movement in water-tube boilers. Tube ruptures and their causes.

That many difficulties are encountered in the production of soft steel suitable for the exacting service to which it is subjected in a steam boiler is evident from the experiments of Dr. C. L. Huston on the segregation of steel ingots in their relation to boiler-plate specifications. In boiler rules the usual range of tensile strength is limited to 45,000 to 55,000 lb. in extra-soft steel; 52,000 to 62,000 lb. in firebox steel and 55,000 to 65,000 lb. for flange steel. An ingot 16x18 in. and weighing 2,600 lb., from which was rolled a plate $\frac{5}{16}$ in. thick,

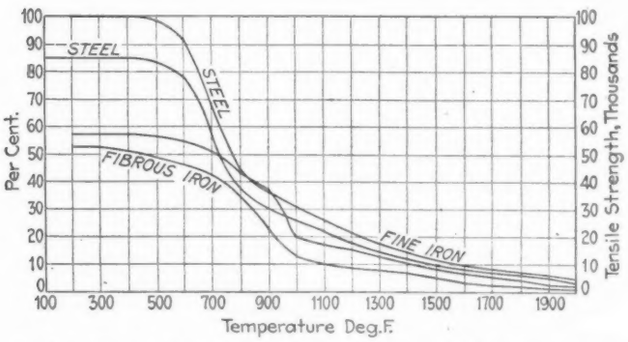


FIG. 1. HOW TENSILE STRENGTH DECREASES WITH INCREASE IN TEMPERATURE OF PLATE

370 in. long and 76 in. wide, showed that the highest carbon content was at the middle of the top end, which had 0.27 per cent. carbon and a tensile strength of 67,050 lb. The edges showed 0.13 per cent. carbon and a tensile strength of 55,490 lb., a difference of over 11,000 lb.

It is instructive to consider what happens to boiler steel in rolling it for boiler plate. With a ½-in. plate rolled for a shell 72 in. in diameter, it is found that the plate remained the same length measured along the neutral axis, but that it had lengthened over 1½ in. on the outer surface and shortened the same amount on the inner surface. This would mean a change, or set, on the surfaces of about 0.008 of the girth measurement at the plate center. The amount of fiber change will be the same for a given thickness of plate regardless of the shell diameter, but the relation of extreme fiber change to diameter will be inversely proportional to the diameters of the shells and directly proportional to the thickness of the plates for the same diameters.

In a shell formed to 40 in. diameter with a plate 1 in. thick, the extreme fiber change would be about 3⅛ in. for each side of the plate and about 0.023 of plate length girthwise. It is apparent that in cases of segregated carbon or other metalloids, serious distress may occur when plates of this thickness are formed cold to small diameters. There seems to be little doubt that within a few years seamless courses will be rolled for boiler shells and drums. This will dispense with riveting and stresses at joints in the shell.

A source of much trouble in the horizontal tubular boiler is the design and workmanship on girth joints. If the shell is 100 per cent. strong, the girth might reasonably be 50 per cent. if the tubes were not considered. As usually designed, these joints have about 42 per cent. of the strength of the plate. This is due to the desire to use the same size of rivet hole throughout on the boiler. An instance of overheating of such a joint came under the writer's observation wherein flange steel failed, breaking into eight separate pieces in an area of 1 sq.ft. This joint had excessive lap, was overcalked, and the rivets were too small.

Another trouble is bagging, or bulging. It is possible to concentrate a fire on the shell or tube of a boiler and heat it to deformation even though the surfaces are clean and the water pure. It is a question of delivering heat to the metal faster than it can be taken away from it.

Fig. 1 shows the results of tests made on bessemer steel to determine tensile strength at temperatures up to 2,000 deg. F. The curves will be found practically correct for openhearth steel and, taken in conjunction with the following formula, will give the approximate temperature at which bulging will occur:

$$\frac{R \times P}{t \times EL} = \text{Per cent. original strength plate}$$

where

R = Radius of shell or tube;
P = Pressure when bulging occurred;
t = Thickness of shell plate or tube;
EL = Elastic strength of plate.

A few years ago the writer was consulted about the failure of a Scotch boiler. The boiler was 11 ft. in diameter, 13½ ft. long and had two Morrison corrugated furnaces 42 in. diameter made from $\frac{7}{16}$-in. plate. These furnaces connected with a combustion chamber, or a wet back. The rear stay-plate which failed was $\frac{15}{32}$ in. thick. This plate was supported by 178 stay-bolts ⅛-in. outside diameter, pitched 7¼x7¼ in. The stay-plate in many places showed bulges of ⅜ in., while the stay-bolts had the heads broken off. The safety valves were set at 105 lb. Failure occurred from stripping of the stay-bolts that held the rear stay-plate in position. The initial failure appeared to be at the second horizontal row of stays from the top, which was incidentally the point at which much of the bulging between the stays occurred.

To check the conclusions arrived at from the inspection, a series of tests was made with stay-bolts in plates shaped similar to parts of the bulged stay-plate. In the first test a stay-bolt with the usual thread and head took a load of 29,100 lb. at the elastic limit and failed at 46,401 lb., stripping the stay-bolt. The equivalent gage pressure is 564 lb. at the elastic limit and 893 lb. at the point of failure.

In a second test with the plate bulged ⅜ in. and the stay headed as in the first test, the threads began to yield at 26,000 lb. and failed at 28,800 lb. The equivalent gage pressure is 522 lb. when yield commenced and 557 lb. at failure. A third test was made on a stay-bolt without a head and a plate buckled ⅜ in. This bolt stripped at 24,800 lb., which is the equivalent of 407-lb. gage pressure.

To determine the behavior of a flat stayed surface under varying conditions of heat and pressure, a steel cylinder was

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made up having a plate (head) 0.447 in. thick on one side and one 0.517 in. thick on the other, the distance between plates being 4 in. The stay-bolts were 1⅛ in. diameter, with 12 threads per inch, and the spacing was 7¼x7¼ in.

A physical test of the 0.447-in. plate gave the elastic limit as 42,846 lb. and an ultimate strength of 52,539 lb. To determine the ultimate elastic strength of this plate, a hydrostatic pressure was applied. A straight-edge applied to the sheet 0.447 in. thick showed that it was practically flat and true. A pressure of 370 lb. was applied and a bulging of be-

FIG. 2. WHERE PIPE IS ATTACHED TO TRANSMIT MOVEMENT OF TUBE TO CHART

tween $\frac{1}{16}$ and ⅛ in. was noticed, which disappeared on the release of the pressure. A pressure of 400 lb. was applied, and on release a set of 0.02 in. was evident. Upon the release of a pressure of 455 lb., a set of 1¼ in. was found between the stays.

To determine the effect of heat on a flat stayed surface similar in design to that of the defective boiler, an air pressure of 95 lb. was maintained on the sample and a flame was made to impinge against the surface. The 0.447-in. plate under an internal pressure of 95 lb. took a set at 1,075 deg. F. and the 0.517-in. plate at 1,275 deg. F.

A vital factor in this problem lies in the destructive stresses induced in the stay-bolts by the overheating of the rear stay-plate and the destructive movement on the threads. In the boiler under discussion this plate had at times an expansion of about ⅝ in., and the effect would be cumulative from the bottom toward the top. The sheet was held at the bottom by straps to the shell, but was free to expand upward.

The foregoing tests show clearly the necessity of renewing stays to a flat surface when bulging occurs. To be convinced of this necessity, take a piece of plate ½ in. thick with the edge squared. Bend the piece to conform to the shape of a bulge. By measurement it will be found that the least amount of bulging draws the threads of the bolt and the hole apart inside, and tightens them on the outer end. Under such conditions the system is no stronger than the thread contact plus the strength of the head of the stay. The necessity for a high factor of safety on stays is clearly indicated. Stay-bolts and rivets should be considered from and at their elastic limit as against the ultimate strength of the plate.

To bring out the possibilities of temperature differences between plates, reference was made to the Munoz boiler explosion at Pabst's brewery in 1909. The boiler had 36-in. drums made from ⅜-in. plate. The shell was reinforced by a ⅝-in. plate riveted to the outside of the shell by a single row of rivets at each side of the ligament strip. The boiler was calculated to carry 150 lb. pressure with a factor of safety of 5. It was shown that considerable trouble had been experienced from leakage at the rivets and tubes due to stresses set up by differences in temperature in the plates. A steam pressure of 150 lb. indicated a temperature of 365 deg. F. The furnace temperature would be upward of 2,500 deg. It was known that water leaked through this strip and as a result, scale formed. A rather high temperature difference would be set up with the ⅝-in., or outer, strip in compression and the ⅜-in. shell plate in tension.

Theoretically a difference of 300 deg. F. should reach the ultimate strength of the shell plate under these conditions, but more or less yield at the rivets and an inclination to bulge out and pull on the tubes would modify the destructive effect in a measure. The significant fact is that the normal load on the shell was about 20 per cent. of the ultimate plate strength. This reinforcing strip, which was used to increase the plate strength between the tube holes, was the actual inciting cause of the disastrous failure of the boiler.

In an experimental observation made recently to ascertain the temperature differences in a construction somewhat similar to that in the Munoz boiler, but used under conditions where there was little chance for trouble, the temperature differences were found instructive. Three pieces of plate 6 in. square and ½ in. thick were used. These plates were riveted together with seven $\frac{3}{8}$-in. rivets. A copper rim was soldered around the top side to provide a pan, and the device was filled with water. A temperature of 600 deg. F. was maintained on one side, and the water was kept at 210 deg. F. The temperature difference between the centers of the outside plates under these conditions remained at 40 deg. It will be understood that the seven rivets were exposed to the fire on one side and to the water on the other.

The author had observed high temperatures on girth joints of horizontal tubular boilers. In one case the temperature ran above 1,500 deg. at the rear girth seam on the lap of the joint. A fire crack, so called, is the result of repeated heatings. While hot the plate finally takes a set in compression, and on cooling it can not resume its original position, but cracks opposite a rivet hole. In extreme cases it may crack or break elsewhere. This is not evidence of poor material.

Observations were made on a boiler to ascertain as nearly as possible what happened to the front tubes during the operation of the boiler. The boiler is a standard 450-hp. Stirling with four drums and three banks of tubes with four rows to each bank and 19 tubes in each row.

This boiler was fitted with a Murphy stoker. It was observed that a permanent set of 2½ in. existed in the tubes of the front row, with the maximum set 54 in. from the mud drum. New tubes were installed in place of a few defective ones. A bolt ⅜ in. diameter was welded to the side of a new tube in the front row and a ⅜-in. pipe was attached to this bolt, as shown in Fig. 2. Circulation of water was maintained and kept at constant temperature. A record of the tube movement was communicated to the ribbon of a CO_2 recorder through the ⅜-in. pipe mentioned.

The boiler was fired up in the usual manner, and it was observed that the tube alternately moved toward the fire from its zero position and from the fire beyond the zero about $\frac{1}{16}$ in., giving a total movement of ⅛ in. This swing occurred every 4 or 5 min. As the water grew hotter the movement tended more from the fire, and when steam was formed the movement gradually increased to about ½ in. from the zero position away from the fire. Fig. 3 clearly shows the frequency and character of this movement, which amounted to a maximum of ½ in. This bending was opposite to the bends at each end of the tube, which were 8½ in. at the bottom and 2½ in. at the top. It is evident that the side of the tube farthest from the fire actually became the hottest. The tube was 17½ ft. long and 3¼ in. diameter. It was found that the lower drum rotated 1 deg. The boiler was operated at slightly above normal.

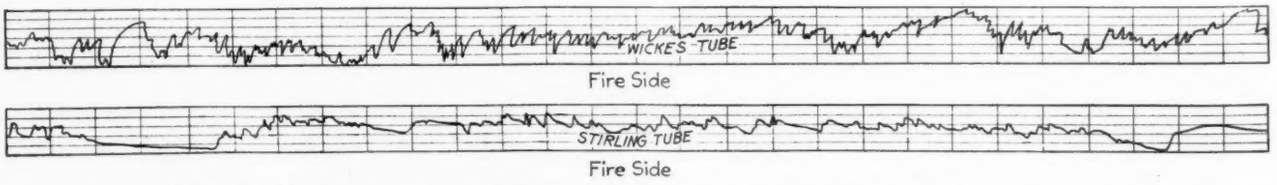

FIG. 3. SHOWING MOVEMENT—ABOUT ONE-HALF ACTUAL—OF TUBES IN WICKES AND STIRLING BOILERS

Observations were made on a 400-hp. Wickes boiler with 4-in. tubes 22 ft. long at the Packard Motor Co.'s plant. At a point on a front tube about 10 ft. 6 in. from the lower

drum a piece of ⅜-in. pipe was attached to a circular plate that served to hold the pipe radial to the tube. Water was circulated to keep the temperature constant. A Murphy furnace was attached to this boiler in the usual manner. The deflection, which is shown in Fig. 3, reached a maximum of ⅝-in. The sharp curves occurring between 11 and 12 o'clock are due to the breaking up of fires. The movement of this tube is away from the fire, as in the case of the Stirling boiler just mentioned, and was proportionately about the same. It may appear that the force required to bend these tubes would be considerable. One of these 4-in. tubes, with the ends free, showed a deflection of ⅝ in. when a load of 187 lb. was placed at its center.

Observations were made on a Stirling "W" type boiler at Delray to find the reason for a tube in the row nearest the fire on one side of the boiler pulling out of the lower drum. The tube was hurled across the space over the fire and flattened two other tubes slightly, but did not loosen them. The upper end of the tube remained in its place in the top center drum. Fig. 4 shows the tube as bent and two views of the end that was pulled from its place in the lower drum. At the end of the tube marked "fire side" it will be seen that a slight scale formed between the tube and plate prior to its ejection. This is conclusive evidence that the tube had taken a set toward the fire. On the other side slight scale formation will be noticed where the tube had taken two different positions on its way out of the tube hole. There is evidence of good expanding and belling, as shown by the clearly defined mark where sharp contact was made on the inner edge of the tube hole.

Experiments showed that a No. 10 gage tube would have to be shortened ¼ in. before it would be flush with the tube sheet on the inside of the drum, and the force required to do this was measured as 285 lb. For the complete ejection of the tube a force of 600 lb. was required with a movement or shortening of the tube of ½ in. The 600-lb. load caused a slight set in the tube.

The tube had been heated probably one or more times to a temperature that caused it to lose about one-half its strength. This would cause it to expand more than the other tubes, and leakage would make possible the scale formation shown in the illustration. For some time before ejection the tube was ⅛ in. outside the inner edge of the tube hole. This is indicated by the scale formation.

Measurement of the tube after ejection showed that it was slightly flat, measuring 3.2811 in. ($3\frac{5}{32}$ in.) on its greatest diameter and 3.2343 in. ($3\frac{15}{64}$ in.) on its lesser diameter. This gives a mean of 3.2578 in. for the diameter of the tube at the point of bearing in the tube sheet. The tube hole was machined 3.281 in. ($3\frac{5}{32}$ in.) and tended to enlarge from the use of the expander. It will be seen that the tube after ejection was 0.023 in. less in diameter than it was while in the tube sheet. This shows that the tube had been heated in excess of the temperature in the tube sheet, causing a set in compression. This temperature was determined experimentally to be above 1,100 deg. F.

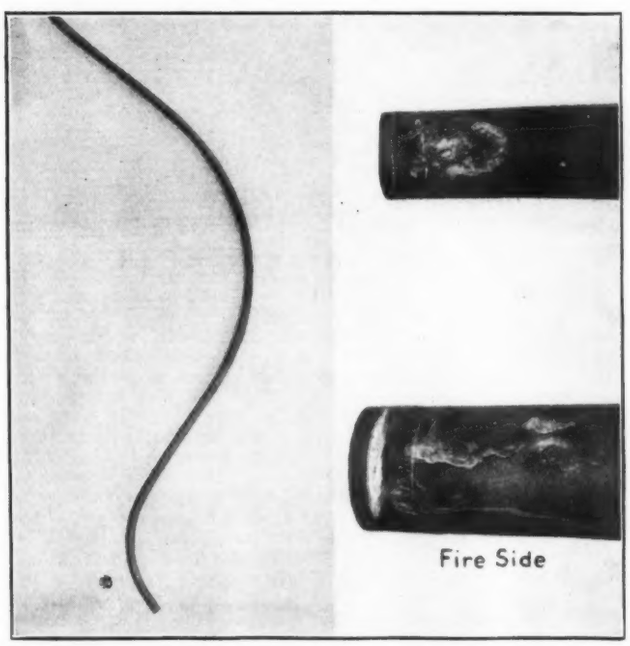

FIG. 4. WARPED TUBE FROM STIRLING BOILER AND BURNED TUBE ENDS

FIG. 5. AFFECTED BY HIGH FURNACE TEMPERATURES

A test was made with a piece of 3¼-in. tube 0.14 in. thick and expanded into a 1-in. plate to determine the load, applied 22 in. from the tube sheet, that would cause yielding. A slight movement was noticed at 1,800 lb., but the tube remained tight in the sheet up to 2,500 lb., at which failure began, the load running up to 2,700 lb. with the tube nearly out of the sheet. The deflection was about 1 in. at the end of the tube.

Another test was made with a load of 500 lb. applied 22 in. from the end of the tube. A flame was projected against the tube sheet and the tube end and the behavior of the tube observed. Yield began at 800 deg. F. At 1,100 deg. the load was dropped to 400 lb. with a deflection of ½ in. On cooling, the tube was slightly loose in the sheet. This tube, properly expended, would require 56,000 lb., or 8,000 lb. gage pressure, to induce yield. The tube would reach the yield point at about 4,000 lb. on its longitudinal section. It is evident that heavy tubes are not essential.

The tube, which is 21.5 ft. long (258 in.), would expand 0.00167 in. per degree. To expand and throw a point in the tube 23 in. from the tube sheet 1 in. lower would require a temperature of $1 \div 0.00167 = 597$ deg. The temperature of the steam was 391 deg. and $597 + 391 = 988$ deg. F., the uniform lowest temperature that would bend what may be called the lever arm to the ejection point. Considered as a column 21.5 ft. long, at a temperature of about 1,000 deg. F. it would not support itself. It is evident that this tube was loosened because of high temperatures at the point of junction with the tube sheet.

The front tubes (of a Stirling boiler) will naturally take more heat than the tubes farther back, in the same bank. The bending moments will tend to work and compress the metal of the tube where bearing in the tube sheet. There is also a slight tendency to elongate the tube hole from the internal pressure. A shell 1 in. thick and coated with oil would admit of considerable rise in temperature in the tube sheet, which, with ordinary furnace temperatures, would have a surface differential of about 15 deg. F. Its temperature, however, may be considerably above that of the steam and water in the boiler.

If the boiler is assumed to be working at 150 per cent. of rating, there would be a heat exchange per square inch per hour of 43.63 B.t.u., or 0.612 B.t.u. per sec. per sq.in. With the Smithsonian constant of 0.0005 unit per deg. F. for one inch of metal, a surface differential of 24 deg. F. would be obtained. This temperature condition would not seriously affect the holding strength of the tube, as the diameter at the outer side of the tube hole would be enlarged only 0.0005 in. The higher temperature on the outside surface would set up an internal stress equal to 2,340 lb. per inch length of shell or drum. As this stress increases with the thickness of the metal, it is undesirable to use thick plates for direct fire contact.

Neglecting the stress due to the expanding of the longitudinal rows of tubes, a temperature of 1,100 deg. F., with 220 lb. pressure, would be required to strain the lower drum through the ligament to the yield point. For the drum in the solid, a temperature of 1,300 deg. would be required.

Temperature measurement of one of the lower drums on another boiler of the same (Stirling) type between the twelfth and thirteenth tube on the row near the fire and 18 in. from the side wall gave a reading of 500 deg. F. at 100 per cent. of rating and 550 deg. at 150 per cent.; the pressure was 210 lb. The theoretical temperature would be about 391 + 24 = 415 deg. F. for 150 per cent. of rating and 391 + 15 = 406 deg. for 100 per cent. The excess of 550 — 415 = 135 deg. in the first case and 500 — 406 = 94 deg. in the second is probably because the tube ends project ⅜ to ½ in. into the drums and pocket a film of steam, with a resultant rise of temperature. The induced temperature does not endanger the boiler, but the drum would be more efficient where exposed if a few tube ends were beaded close to the shell after slightly tapering the tube hole.

The increase of temperature in the drum to 1,100 deg. F. would cause the diameter of the hole to increase only 0.0045 in. This would not account for the pulling out of the tube which projected into and beyond the inner side of the drum ½ in. and was belled at the end to over one-fourth the nominal diameter. Considerable oil was observed in the lower drum and may account for a temperature rise sufficient to allow the tube to be pulled out.

An observation of the front tubes in the boiler on which the accident occurred showed that their movement does not exceed ⅛ in. and that it is not sudden. The mud drum moved ⅝ in. in a direction down and from the fire, and it was apparently a movement due to the increase of temperature in the tubes. No rotation of the drum, such as was found at the Detroit United Railways' plant was evident. The apparent movement of the front tubes toward the fire is due to general causes rather than to local heating. The front tubes

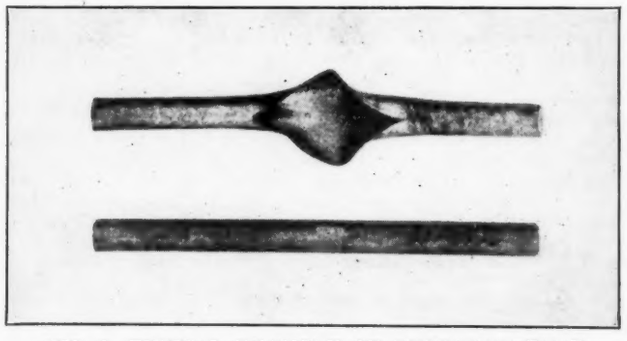

FIG. 6. TYPICAL EXAMPLE OF RUPTURED TUBE

form an angle of about 10 deg. to the vertical. The distance of the lowest point of the tubes above the grates prevents flame contact with much of the tubes, and the heat from 10 to 15 tons of burning coal to the front banks of tubes from opposite sides of the furnace (a Murphy furnace) envelops the tube banks equally.

For years the impression has prevailed that the furnace should be placed close to the boiler. This practice has been a source of many boiler troubles and should be discontinued. The Wickes and Stirling boilers mentioned would have shown less tube movement if the stokers had not been placed so close to the boilers. This practice not only produces serious local heating, but also lessens the economy of operation.

One of the serious troubles experienced in the operation of water-tube boilers is the rupture of tubes. Several experiments have been made by the writer to determine the conditions under which a tube will rupture, bag or bulge.

A 3¼-in. seamless steel tube 0.13 in. thick, having a tensile strength of 55,800 lb. and an elastic limit of 46,600 lb., was used, the elastic limit being 83.5 per cent. of the tensile strength. It was desirable to ascertain at what temperature this tube would yield or take a deformation under an internal pressure of 200 lb. of air. Calculated from its elastic limit, 4,052 lb. is indicated as the pressure at which this tube would begin to yield under a temperature of 400 deg. F. or less. By the usual formula and the curves in Fig. 1, about 2,000 deg. F. was calculated to be the yield temperature.

The tube under 200 lb. pressure was heated to 2,000 deg. F. and upon cooling the diameter was found to have increased ⅜ in. Several similar tests were made with the same approximate results. These tests show clearly to about what temperature a cylindrical vessel must be heated before it will deform under a given pressure.

Fig. 5 shows the effect of heat on some tubes. No. 1 tube was filled with steam at 75 lb. pressure, and an acetylene flame was projected against its wall. It was pierced in 15 sec. No. 2 was filled with water at 77 deg. F., and the flame pierced it in 30 sec. The water was raised to 90 deg. F. One inch from where the flame came in contact with the tube, a sensitive Hoskins pyrometer couple was inserted and indicated a temperature rise of only 43 deg. F. It is estimated that 230 B.t.u. were projected against the tube in the 30 sec.

FIG. 7. SHOWING HOW TUBE IS WARPED TOWARD THE FIRE SIDE

This would be upward of about 1,400 times as much heat as would be projected against a boiler ordinarily and then not so directly. Tube 3 shows the result of a pressure-heat test where the heat was localized. Rupture occurred at 2,300 deg. with 125-lb. air pressure. Tube 5 shows the results of a similar test. The temperature applied was estimated at 2,500 deg. F.

It was desired to cause a rupture in a 3¼-in. seamless steel tube in a manner similar to those of frequent occurrence in water-tube boilers. The tube selected was found to have a tensile strength of 60,800 lb. and an elastic limit of 45,800 lb. On this tube a constant air pressure of 200 lb. was maintained. It was heated to 2,000 deg. F. and quickly taken from the furnace and a stream of cold water played over it for about 1 ft. of its length. This was repeated several times, but without result. Finally the tube was heated to 2,100 deg. F., and it ruptured with a mild explosion, tearing longitudinally for 18 in., the opening being 10 in. wide and the reaction bending the tube back. Fig. 6 shows the ruptured tube and

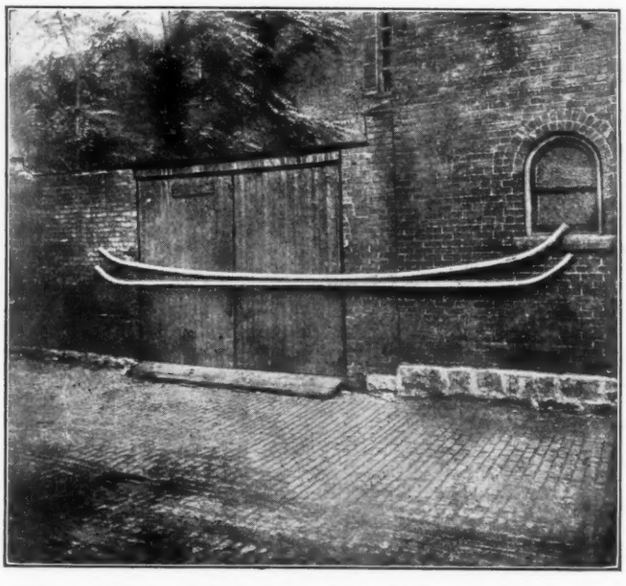

FIG. 8. STIRLING TUBE WITH DEFORMATION OF 6 IN. TOWARD FIRE

the tube tested to its yield point. The tube under 200 lb. air pressure was heated to 1,975 deg. F. On cooling, the diameter had increased ⅜ in. Fig. 7 shows a tube taken from a standard Stirling boiler; the tube had a set of 2½ in. from the fire. Fig. 8 shows a Stirling tube with a deformation toward the fire of about 6 in. The behavior of tubes under flame contact is to bend away from the fire. If scale collects or the water is low, the tube moves toward the fire.

There can be no doubt that boiler tubes fail from being heated somewhat above the yield point of the metal for a few inches of their length. Boiler metals under high temperatures do not increase in tensile strength like metals, whose strength increases with temperature increase up to about 400 deg. The latter obtain a higher tensile strength when loaded beyond the yield point. At high temperatures any yield under load precipitates failure.

The fact that a tube has been overheated can readily be told by the use of a tape. Occasionally a welded tube fails from structural weakness. The rupture of a tube produces

much the same phenomena that occur in a boiler explosion. After the initial rupture there is a pressure drop in the tube, followed by an explosive rate of evaporation of much of the water in the tube. This causes the projection of water from both ends of the tube toward the point of low pressure, producing an extended rupture through the solid metal of the tube. Ruptures in tubes are invariably caused by the presence of nonconductors on the inside of the tube wall. Greater care should be taken to purify feed water for boilers. Flame contact on tubes is sure to cause heavy deposits of sediment at the points of impingement.

Pan-American Congress

The second Pan-American Scientific Congress under the auspices of the State Department was held in Washington, D. C., Dec. 27, 1915, to Jan. 8, 1916, inclusive. The first was held at Santiago, Chile, Dec. 25, 1908, to Jan. 5, 1909. The object of the congresses is to foster a closer and more cordial relation between North, Central and South America in every way possible and especially along scientific lines. The delegates consisted of representatives from all of the Central and South American countries (numbering in all about 400) and representatives of American associations, societies, universities and scientists connected with the Federal Government. The main activities of the congress were divided into the following sections and further divided into subsections as found necessary: (I) Anthropology; (II) Astronomy, Meteorology and Seismology; (III) Conservation of Natural Resources, Agriculture, Irrigation and Forestry; (IV) Education; (V) Engineering; (VI) International Law, Public Law and Jurisprudence; (VII) Mining and Metallurgy, Economic Geology and Applied Chemistry; (VIII) Public Health and Medical Science; (IX) Transportation, Commerce, Finance and Taxation.

All sessions were open to the public, but the receptions were restricted to members. The meetings of section V (Engineering) and its subsections were held at the Raleigh Hotel, with few exceptions. Since the close of the congress the visiting delegates are making an extensive tour of the United States, visiting various points of interest and the larger cities, where officials and organizations have appointed committees and arranged to entertain them. The American Society of Mechanical Engineers, through its secretary, Calvin W. Rice, took an active part in the work at Washington and New York.

Probably no larger or more comprehensive effort to get the people of various countries together has ever been carried out. During the congress there were in simultaneous session under the various sections and subsections upward of 30 meetings daily, dealing with a wide range of subjects. Among the things urged (not included in the engineering section) and of general interest was a uniformity in the coinage or monetary systems of all Pan-American countries, the value of which is acknowledged by all concerned. In section 4 (Education) the central thought was similarity in educational methods in order to bring the Pan-American people in closer touch, and likewise section VI on International Law. The work of section IX on Transportation, Commerce, Finance and Taxation, did much work along lines of particular interest to engineers generally. The chairman of section V (Engineering) was Brig. Gen. W. H. Bixby, United States Army, retired; secretary, Dr. Elmer L. Crothell, North Egremont, Mass.; corresponding secretary, Alberto Smith, 112 West 70th St., New York City.

Following the formal opening of the congress on Monday in the Memorial Continental Hall, the engineering section (V) was opened by General Bixby Tuesday morning and the organization of its subsections was carried out. Doctor Crothell was made chairman of subsection 1, Civil Engineering; Capt. C. A. McAllister, United States Coast Guard, chairman of subsection 2, Marine Engineering; Prof. J. B. Whitehead, Johns Hopkins University, chairman of subsection 3, Electrical Engineering; M. O. Leighton, Washington Society of Engineers, chairman of subsection 4, Reclamation, Sewage and Municipal Water Supply; Prof. Carl C. Thomas, Johns Hopkins University, chairman of subsection 5, Mechanical Engineering; S. W. Stratton, Director of the United States Bureau of Standards, chairman of subsection 6, Standards, Surveys, Parks, Buildings, Nomenclature.

Among the papers presented on Tuesday afternoon in the mechanical engineering subsection was one by William Kent on "Economy of Steam Power Plants Using Gas, Gasoline, Coal and Other Pan-American Fuels." In this paper the author discussed the heat value of all fuels to be obtained in Pan-American countries, including alcohol, tar and corn, giving the results absolute and comparative to be obtained from each and the conditions governing the choice of fuel in a given case and the cost of each item going to make up the total cost of power.

Tuesday evening was devoted to a joint session, at the Pan-American building. Papers were read by Dr. T. W. Carver, of Harvard University, and Dr. H. W. Wiley, and an illustrated lecture was given by Col. W. W. Harts, in charge of the United States Office of Public Buildings and Grounds.

Wednesday, Dec. 29, was devoted largely to matters pertaining to water power, including the laws and regulations regarding the use of water for all purposes. This subject was specially referred to this congress by its predecessor—the first Pan-American congress. In the forenoon papers were presented by H. W. Buck, of New York City, "Present Status of Water Power Development; G. C. P. Da Silva, of Brazil, the "Laws Governing Running Water and Waterfalls"; Rome G. Brown, of Minneapolis, "Laws and Regulations Regarding the Use of Water for All Purposes in North and South America"; Halford Erickson, chairman of the Railroad Commission of Wisconsin, "Regulation and Control of Water Power as a Public Utility by State Commissions."

In the afternoon Prof. G. A. Rouch dealt with "Electrochemical Industries"; Maurice Deutch, "Hydro-Electric Utilization at Niagara and Elsewhere" (illustrated), and Thomas H. Norton, United States Department of Commerce, also dealt with "Niagara Power for Special Purposes."

On Thursday, Dec. 30, papers were presented describing the scientific work of the various branches of the United States Government, including the Bureau of Standards, Corps of Engineers United States Army, United States Reclamation Service and United States Indian Office; also papers by Doctor Corthell; Doctor Tariana, delegate from Colombia; Captain Miranda, of Uruguay; and Mr. Da Silva, of Brazil.

One of the papers of special and timely interest presented Friday, Dec. 31, was by Alberto Smith, of Venezuela, on "Engineering Nomenclature." This subject was referred for discussion to this congress by its predecessor—the first Pan-American congress. The author was in a position to discuss the subject intelligently, especially as to the need of uniformity in the use and exact meaning of various engineering terms by all Pan-American people, by reason of his having lately completed the work of translating "Trautwine's Engineers' Pocket-Book" into the Spanish language. This work was all the more difficult because of the lack of uniformity in the use of engineering terms in the various countries. "Engineering Education in the United States" was discussed by Doctor How, of the Case School of Applied Sciences.

On Monday, Jan. 3, papers were presented on "Electric Current Flow," by Dr. Bautute Laynty; "Electric Power Transmission and Distribution Systems," by Percy H. Thomas; "Aluminum Conductors," by Theodore Varney; "Underground Cables," by H. W. Fisher; and "Chronocyclograph Motion Devices for Measuring Achievement," by Frank B. Gilbreth. In the afternoon the engineering and other scientific work of the United States Coast and Geodetic Survey and United States Geological Survey were dealt with by E. Lester Jones and R. B. Marshall, in charge of the work of the two branches respectively.

Tuesday morning, Jan. 4, was given largely to harbor works and terminals in subsection 1, and in subsection 3 to a paper by F. B. Jewett, assistant chief engineer, Western Electric Co., on "Recent Telegraph and Telephone Development." In the afternoon a paper by Edward B. Rosa, United States Bureau of Standards, on "Electric Codes and Standards," and other papers on kindred subjects were presented.

Wednesday, Jan. 5, "Uniform Gage for Railways in Pan-America," by Fred Lavis, and like discussion occupied the forenoon, and in the afternoon a test, to destruction, of a concrete slab 32 ft. long by 16 ft. wide and 9 in. thick, was witnessed at Arlington farm, after which a special exhibition drill was given by United States troops at Fort Myer in honor of the members of the congress. Wednesday evening, under the auspices of the Washington Society of Engineers, Dr. John A. Brashear delivered an illustrated address entitled "An Evening Journey Among the Stars," which was particularly enjoyable and instructive.

Thursday and Friday (Jan. 6 and 7) were spent in arranging and compiling resolutions and suggestions at joint sessions of all subsections of section V. President Wilson addressed the members Thursday evening at the Pan-American building. Saturday, Jan. 8, the congress was formally closed by the adoption of the various resolutions at a joint session of all sections.

There being no available funds for printing the papers presented, only a few are available, those printed and furnished by their authors. It is expected that Congress will later appropriate funds for printing these excellent papers, many of which are in two languages, thus enhancing their value for the purpose intended—namely, a closer relationship between Pan-American countries.

If what may be called political and governmental questions somewhat overshadowed strictly scientific questions, it was with the consent of the scientists present. They, as others,

recognized the fact that the momentous new times had put general questions into the foreground and demanded their consideration. What the public has heard much about during the sittings of the congress has related to matters other than scientific—the Monroe doctrine, the value and growth of democracy, the belief that this hemisphere is dedicated to the rule of the people and that the people of both continents should act in sympathy with that belief and in coöperation to that end. Both the President and Secretary Lansing spoke in that vein, and all the other deliverances carried a similar message.

The next congress will assemble at Lima five years hence. Time and place carry assurance of another successful meeting, as Peru is progressive and hospitable, and as host will forward all the purposes disclosed here.

Power Plant To Generate Steam at 350 Lb. Pressure

A steam pressure of 350-lb. gage and on top of this 225 deg. of superheat, corresponding to a temperature of 661 deg., is a long step in advance over average practice in the best power plants of the country. For a number of years the range of working pressures has been increasing. Lower vacuums are now obtained than ever before, and initial pressures have been mounting by slow degrees. Realizing the possibilities for higher economy, the Public Service Co. of Northern Illinois has moved suddenly beyond the beaten path and decided to install a station in which steam will be generated at the pressure and superheat previously mentioned. It has just been determined to locate the plant one mile south of Joliet, on the Desplaines River. The site affords plenty of cooling water for condensing purposes and is served by the Chicago & Alton and the Atchison, Topeka & Santa Fe railways.

It is proposed to install three standard cross-drum B. & W. boilers, each to contain 10,000 sq.ft. of heating surface, and a built-in superheater made by the same company. There will be individual economizers mounted above the boilers, which will be of steel construction throughout and will resemble closely a B. & W. boiler without the drum. Each unit will contain 6,700 sq.ft. of surface and will be an integral part of the boiler.

Two B. & W. chain-grate stokers will be placed side by side in a common furnace. Each will be 8 ft. wide and contain 116 sq.ft. of active grate area, or 232 sq.ft for the two, which bears a ratio to the heating surface in the boiler of 1 to 43. Illinois screenings will be burned in the furnace. Induced draft will be supplied by motor-driven blowers, and each boiler will have an individual self-supporting steel stack mounted above the economizer. Feed water will be supplied by multi-stage pumps driven by steam turbines, and these will be the only auxiliaries in the plant which are not electrically driven. Bucket elevators will be used to convey the coal from the railway cars to the bunkers.

Two of the boiler units will be used regularly to carry the load, and the third will serve as a reserve. They will supply steam to a turbo-generator of the Curtis horizontal type rated at 12,500 kv.-a. or 10,000 kw. at 80 per cent. power factor. The turbine will have eight stages and will be designed for a working pressure of 300 lb. Space has been reserved for another unit of the same size or larger, depending upon the load conditions at the time it is needed. Provision has also been made for its complement of boilers. The turbine will be equipped with a Westinghouse surface condenser containing 20,000 sq.ft. of surface, or 2 sq.ft. per kilowatt of generator rating. It will be served by a LeBlanc air pump and the usual auxiliaries, which will be motor driven. A back pressure of 0.77 in. abs. is guaranteed.

Three-phase 60-cycle current will be generated at 12,000 volts and will be stepped up to 33,000 volts before it is fed into the transmission system operated by the company to supply towns in the Fox River Valley, Joliet, the Illinois River Valley and as far south as Kankakee and Pontiac.

Every effort will be made to make the station as safe as possible for the employees. Work of clearing the site and installing side tracks has just been started. The plant will probably be completed within a year. It is being designed by Sargent & Lundy, consulting engineers, assisted by Von Holst & Fyfe, architects. It will be operated by the Public Service Co. of Northern Illinois, of which Samuel Insull is president, F. J. Baker vice-president in charge of operation and construction, George H. Lukes general superintendent, and J. L. Hecht mechanical engineer.

OBITUARY

ROLLIN E. HOWLAND

Rollin E. Howland, assistant engineer at the Pittsfield (Mass.) generating plant of the General Electric Co., was killed on the afternoon of Jan. 9 while making a test behind the station switchboard. Mr. Howland was standing on a stepladder behind the 2,300-volt busses of the board, and while taking down an instrument used in testing, his head came in contact with the busbars, resulting in burns and shock, which caused his death before the arrival of medical assistance. He was a native of West Stockbridge, Mass., and was 41 years of age, having been employed at the Pittsfield plant twelve years. Mr. Howland is survived by his widow and two children.

PERSONALS

W. J. A. London, for the last nine years chief engineer of the Terry Steam Turbine Co., Hartford, Conn., recently became associated with the Sterling Blower Co., Hartford, Conn.

William Jameson has been appointed superintendent of power at the plant of the Fisk Rubber Co., Chicopee Falls, Mass. He has been connected with the company since its predecessor, the Spalding & Pepper Co., began the manufacture of bicycle tires at Chicopee Falls. In his new position he will have charge of all matters relating to power in the plant, including machine, carpenter, pipe, electric and welding shops.

Charles H. Hersey, of the Boston "Transcript" engineering staff, completed 50 years of service with the paper on Jan. 10. From the "Transcript" company he received a gift of $100 accompanied by a letter of appreciation of his long and faithful service as an operating engineer, and some of his associates presented him with $50 in gold as a mark of friendship. Mr. Hersey is in excellent health and was 70 years of age last October.

E. G. Bailey, of Boston, familiar to "Power" readers on account of his contributions to its columns and to the proceedings of various societies of papers and discussion upon fuel and combustion, has organized the Bailey Meter Co. to manufacture and sell a complete line of recording meters and instruments for power-plant and similar uses. The Fuel Testing Co., with which Mr. Bailey has been identified, will be continued under the direction of W. B. Calkins, who has been Mr. Bailey's partner in that enterprise since its organization in 1909.

ENGINEERING AFFAIRS

National Electric Light Association—It has been decided to hold the thirty-ninth convention during the week of May 22, in Chicago. The headquarters will be at the Congress and the Auditorium Hotels, where it is proposed all the meetings shall be held as well as the annual exhibit.